SCIENTIFIC AMERICAN SUPPLEMENT. No 1739

Entered at the Post Office of New York, N. Y., as Second Class Matter.
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Published weekly by Munn & Co. at 361 Broadway, New York.

Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York.

Scientific American, established 1845.
Scientific American Supplement, Vol. LXVII., No. 1739.

NEW YORK, MAY 1, 1909.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

A NOVEL STEAM TRACTOR FOR HAULING LOGS OVER SNOW.

Some months ago we illustrated a machine known as a "caterpillar" tractor, in which the propelling device was a broad, flat endless chain. This machine was of English origin. It was propelled by a gasoline motor and was capable of traveling over all kinds of rough and boggy ground.

The machine shown in the accompanying illustrations is equipped with a similar propelling mechanism, but it is a steam locomotive intended for hauling logs on sleds over snow-covered roads or tracks in winter.

This snow tractor consists of a locomotive-type, water-front pattern boiler mounted upon a heavy channel-iron frame of sufficient length to accommodate a cab and coal bunker in the rear and a seat for the pilot at the front. The forward end of this frame is mounted upon a pair of runners that can be turned by the steering wheel in order to steer the tractor. The rear end of the frame is carried upon two large sprocket-like wheels on each side, each pair of these wheels being encircled by (and thus resting upon) an endless band made up of "links" consisting of steel castings 16 inches wide by 2 inches thick. On the outside of each pair of sprocket wheels is a cast-iron runner upon which, near each end, are mounted the journals of the sprocket-wheel shafts. The runners themselves are pivoted at their center points upon a transverse shaft attached to the channel-iron frame.

On the outside of each runner are two small sprockets, over which is stretched an endless tool-steel roller chain. This chain bears against the outer one, and keeps it flat regardless of uneven spots in the road. On the lower part of the frame carrying this roller chain there is a renewable grooved shoe, which takes the wear. The rear grooved sprocket wheels are carried in adjustable bearings, and are driven from the countershaft in front by a chain, which runs upon a special parallel sprocket mounted upon the same shaft. The countershaft is provided with a differential gear, and a

THE TRACTION ENGINE.

HAULING SAWN TIMBER OVER THE ICE.

A NOVEL STEAM TRACTOR FOR HAULING LOGS OVER SNOW.

spur pinion on the engine crankshaft drives a large gear on the differential. The differential gear is inclosed in an oil-tight casing, and thus it can be thoroughly lubricated. The gears and sprockets are made of the best steel, and are sufficiently strong to transmit the 100 horse-power which the engine is capable of developing with the regular working pressure of 175 pounds. A speed of 4 to 5 miles an hour can be made under ordinary circumstances; and while the tractor will work in very rough country, better results are had when the grades and turns are easy.

The cab of the locomotive is fitted up like that of any ordinary steam locomotive. There is a quadrant and lever for reversing. The regular type of locomotive throttle is used, and each engine has a double sight-feed lubricator, two injectors, oil and grease cups, a whistle, and a large ejector for taking water. The locomotive complete, without water, weighs 15 tons, while with water sufficient to run it a distance of four or five miles, it weighs about 18 tons. It is capable of hauling from seven to fifteen heavy logging sleds, carrying 5,000 to 7,000 feet of logs per sled, at a speed of four to five miles per hour on well-graded and icy roads. One user of this locomotive claims to have effected a saving of about $1 per cord in hauling 2,000 cords of pulp wood a considerable distance across country and over grades of from 15 to 20 per cent. The photograph shows the tractor hauling a 200,000-pound train of loaded sleds in Canada.

The above description shows the endless-band form of drive to be equally as good upon icy and snow-covered roads as upon all kinds of ordinary rough ground; and we have no doubt that these locomotives will be rapidly introduced into the logging camps in the north of the United States and in Canada.

THE TYPHOID FLY OR HOUSE FLY.*

A DANGEROUS COMMON INSECT.

BY L. O. HOWARD, PH.D.

THE name "typhoid fly" is here proposed as a substitute for the name "house fly," now in general use. People have altogether too long considered the house fly as a harmless creature, or, at the most, simply a nuisance. While scientific researches have shown that it is a most dangerous creature from the standpoint of disease, and while popular opinion is rapidly being educated to the same point, the retention of the name house fly is considered inadvisable, as perpetuating in some degree the old ideas. Strictly speaking, the term "typhoid fly" is open to some objection, as conveying the erroneous idea that this fly is solely responsible for the spread of typhoid, but considering that the creature is dangerous from every point of view, and that it is an important element in the spread of typhoid, it seems advisable to give it a name which is almost wholly justified and which conveys in itself the idea of serious disease. Another repulsive name that might be given to it is "manure fly," but recent researches have shown that it is not confined to manure as a breeding place, although perhaps the great majority of these flies are born in horse manure. For the end in view, "typhoid fly" is considered the best name.

The true connection of the so-called house fly with typhoid fever and the true scientific evidence regarding its rôle as a carrier of that disease have only recently been worked out. Celli in 1888 fed flies with pure cultures of the typhoid bacillus, and examined their contents and dejections microscopically and culturally. Inoculations of animals were also made, proving that the bacilli which passed through flies were virulent. Dr. George M. Kober, familiar with Celli's researches, in his report on the prevalence of typhoid fever in the District of Columbia, published in 1895, called especial attention to the danger of the contamination of food supplies by flies coming from the excreta of typhoid patients. The prevalence of typhoid fever in the concentration camps of the United States Army in the summer of 1898 brought about the appointment of an army typhoid commission consisting of Drs. Walter Reed, U. S. Army, Victor M. Vaughan, U. S. Volunteers, and E. O. Shakespeare, U. S. Volunteers. A paper read by Doctor Vaughan before the annual meeting of the American Medical Association at Atlantic City, N. J., June 6, 1900, contained the following conclusions with regard to flies:

"27. *Flies undoubtedly served as carriers of the infection.*

"My reasons for believing that flies were active in the dissemination of typhoid may be stated as follows:

"*a.* Flies swarmed over infected matter in the pits and then visited and fed upon the food prepared for the soldiers at the mess tents. In some instances where lime had recently been sprinkled over the contents of the pits, flies with their feet whitened with lime were seen walking over the food.

"*b.* Officers whose mess tents were protected by means of screens suffered proportionately less from typhoid fever than did those whose tents were not so protected.

"*c.* Typhoid fever gradually disappeared in the fall of 1898, with the approach of cold weather, and the consequent disabling of the fly.

"It is possible for the fly to carry the typhoid bacillus in two ways. In the first place, matter containing the typhoid germ may adhere to the fly and be mechanically transported. In the second place, it is possible that the typhoid bacillus may be carried in the digestive organs of the fly and may be deposited."

There were also many important conclusions which bear upon the fly question. For example, it was shown that every regiment in the United States service in 1898 developed typhoid fever, nearly all of them within eight weeks after assembling in camps. It not only appeared in every regiment in the service, but it became epidemic both in small encampments of not more than one regiment and in the larger ones consisting of one or more corps. All encampments located in the Northern as well as in the Southern States exhibited typhoid in epidemic form. The miasmatic theory of the origin of typhoid fever and the pythogenic theory* were not supported by the investigations of the commission, but the doctrine of the specific origin of the fever was confirmed. The conclusion was reached that the fever is disseminated by the transference of the excretions of an infected individual to the alimentary canals of others, and that a man infected with typhoid fever may scatter the infection in every latrine or regiment before the disease is recognized in himself, while germs may be found in the excrement for a long time after the apparently complete recovery of the patient. Infected water was not an important factor in the spread of typhoid in the national encampments of 1898, but about one-fifth of the soldiers in the national encampments in the United States during that summer developed this disease, while more than 80 per cent of the total deaths were caused by typhoid.

In 1899 the writer began the study of the typhoid or house fly under both country and city conditions. He made a rather thorough investigation of the insect fauna of human excrement, and made a further investigation of the species of insects that are attracted to food supplies in houses. In a paper entitled "A Contribution to the Study of the Insect Fauna of Human Excrement (with special reference to the spread of typhoid fever by flies)," published in the Proceedings of the Washington Academy of Sciences, Volume II, pages 541-604, December 28, 1900, he showed that 98.8 per cent of the whole number of insects captured in houses throughout the whole country under the conditions indicated above were *Musca domestica*, the typhoid or house fly. He showed further that this fly, while breeding most numerously in horse stables, is also attracted to human excrement and will breed in this substance. It was shown that in towns where the box privy was still in existence the house fly is attracted to the excrement, and, further, that it is so attracted in the filthy regions of a city where sanitary supervision is lax and where in low alleys and corners and in vacant lots excrement is deposited by dirty people. He stated that he had seen excrement which had been deposited overnight in an alleyway in South Washington swarming with flies under the bright sunlight of a June morning (temperature 92 deg. F.), and that within 30 feet of these deposits were the open windows and doors of the kitchens of two houses kept by poor people, these two houses being only elements in a long row. The following paragraph is quoted from the paper just cited:

"Now, when we consider the prevalence of typhoid fever and that virulent typhoid bacilli may occur in the excrement of an individual for some time before the disease is recognized in him, and that the same virulent germs may be found in the excrement for a long time after the apparent recovery of a patient, the wonder is not that typhoid is so prevalent, but that it does not prevail to a much greater extent. Box privies should be abolished in every community. The depositing of excrement in the open within town or city limits should be considered a punishable misdemeanor in communities which have not already such regulations, and it should be enforced more rigorously in towns in which it is already a rule. Such offenses are generally committed after dark, and it is often difficult or even impossible to trace the offender; therefore, the regulation should be carried even further and require the first responsible person who notices the deposit to immediately inform the police, so that it may be removed or covered up. Dead animals are so reported; but human excrement is much more dangerous. Boards of health in all communities should look after the proper treatment or disposal of horse manure, primarily in order to reduce the number of house flies to a minimum, and all regulations regarding the disposal of garbage and foul matter should be made more stringent and should be more stringently enforced."

In the opening sentence of the paragraph just quoted attention was called to the activity of bacilli in excreta passed by individuals after apparent recovery from typhoid. Since the paper in question was published, more especial attention has been drawn by medical men to this point, and it has been shown that individuals who are chronic spreaders of the typhoid germs are much more abundant than was formerly supposed. Dr. George A. Soper recently discovered a striking case of this kind in the person of a cook employed successively by several families in the vicinity of New York city, with the result that several cases of typhoid occurred in each of these families. In a paper by Dr. Davids and Prof. Walker, read before the Royal Sanitary Institute of London during the present season, the history was given of four personal carriers of typhoid who had communicated the disease to a number of people. These four carriers were detected in one city within a few months, and from this fact it can be argued with justice that such cases are comparatively numerous. This being true, the presence of unguarded miscellaneous human excreta deposited in city suburbs, in vacant lots, and in low alleyways intensifies to a very marked degree the danger that the food will become contaminated with typhoid bacilli by means of the typhoid or house fly. It is known, too, that the urine of persons who have suffered from typhoid fever often contains active typhoid bacilli for several weeks after the patients have recovered; consequently this also is a source of danger.

The importance of the typhoid fly as a carrier of the disease in army camps, as shown in the Spanish war and in the Boer war and in the camps of great armies of laborers engaged in gigantic enterprises like the digging of the Panama canal, is obvious, but what has just been stated indicates that even under city conditions the influence of this fly in the spread of this disease has been greatly underestimated. It is not claimed that under city conditions the house fly becomes by this argument a prime factor in the transfer of the disease, but it must obviously take a much higher relative rank among typhoid conveyers than it has hitherto assumed. Perhaps even under city conditions it must assume third rank—next to water and milk.

It is not alone as a carrier of typhoid that this fly is to be feared. In the same way it may carry nearly all the intestinal diseases. It is a prime agent in the spreading of summer dysentery, and in this way is unquestionably responsible for the death of many children in summer. One of the earliest accurate scientific studies of the agency of insects in the transfer of human disease was in regard to flies as spreaders of cholera. The belief in this agency long preceded its actual proof. Dr. G. E. Nicholas, in the London Lancet, Volume II, 1873, page 724, is quoted by Nuttall as writing as follows regarding the cholera prevailing at Malta in 1849: "My first impression of the possibility of the transfer of the disease by flies was derived from the observation of the manner in which these voracious creatures, present in great numbers, and having equal access to the dejections and food of patients, gorged themselves indiscriminately and then disgorged themselves on the food and drinking utensils. In 1850 the "Superb," in common with

* Abstracted from Bulletin 78 of the Bureau of Entomology, United States Department of Agriculture.

* This theory is founded upon the belief that the colon germ may undergo a ripening process by means of which its virulence is so increased and altered that it may be converted into the typhoid bacillus or at least may become the active agent in the causation of typhoid fever.

SOURCES OF BACTERIA FROM FLIES.

Date.	Source.	Total Number.	Total Acid Bacteria.	Rapid Liquefying Bacteria.	Slow Liquefying Bacteria.	*Bacterium lactis acidi.* Group A, Class 1.	*Coli-ærogenes.* Group A, Class 2.
1907							
July 27	(*a*) 1 fly, bacteriological laboratory	3,150	250	600	100		
July 27	(*b*) 1 fly, bacteriological laboratory	550	100	0	0		
Aug. 6	(*c*) 19 cow-stable flies	7,980,000	220,000	0	20,000		
	Average per fly	420,000	11,600	0	1,000		
Aug. 14	(*d*) 94 swill-barrel flies	155,000,000	8,950,000	0	0	4,320,000	4,630,000
	Average per fly	1,660,000	95,300	0	0	46,000	49,300
Aug. 14	(*e*) 144 pigpen flies	133,000,000	2,110,000	100,000	266,000	933,000	1,176,000
	Average per fly	923,000	18,700	700	1,150	6,500	12,200
Sept. 4	(*f*) 18 swill-barrel flies	118,800,000	40,480,000	0	14,500,000	10,480,000	30,000,000
	Average per fly	6,600,000	2,182,000	0	804,000	582,000	1,600,000
Sept. 21	(*g*) 30 dwelling-house flies	1,425,000	125,000	0	12,500		
	Average per fly	47,580	4,167	0	417		
Sept. 21	(*h*) 26 dwelling-house flies	22,880,000	22,506,000	120,000	34,000		
	Average per fly	880,000	869,000	4,600	1,300		
Sept. 27	(*i*) 110 dwelling-house flies	35,500,000	13,670,000	8,840,000	125,000		
	Average per fly	322,700	124,200	80,300	1,100		
Aug. 20	(*j*) 1 large bluebottle blowfly	308,700	(*)				
	Total average of 414 flies	1,222,570	367,300	7,830	73,500		
	Average per cent of 414 flies		30	6	6		
	Average per fly of 256 flies, experiments (*d*), (*e*) and (*f*)	3,061,000	765,000	230	268,700	211,500	553,800
	Average per cent of 256 flies, experiments (*d*), (*e*) and (*f*)		25		8	7	18

* 2,200 mold spores.

the rest of the Mediterranean squadron, was at sea for nearly six months; during the greater part of the time she had cholera on board. On putting to sea, the flies were in great force; but after a time the flies gradually disappeared, and the epidemic slowly subsided. On going into Malta Harbor, but without communicating with the shore, the flies returned in greater force, and the cholera also with increased violence. After more cruising at sea, the flies disappeared gradually with the subsidence of the disease."

Accurate scientific bacteriological observations by Tizzoni and Cattani in 1886 showed definitely active cholera organisms in the dejecta of flies caught in the cholera wards in Bologna, Italy. These observations were subsequently verified and extended by Simonds, Offelmann, Macrae, and others.

With tropical dysentery and other enteric diseases practically the same conditions exist. In a report by Daniel D. Jackson to the committee on pollution, of the Merchants' Association in New York, published in December, 1907, the results of numerous observations upon the relation of flies to intestinal diseases are published, and the relation of deaths from intestinal diseases in New York city to the activity and prevalence of the common house fly is shown not only by repeated observations but also by an interesting plotting of the curve of abundance of flies in comparison with the plotted curve of abundance of deaths from intestinal diseases, indicating that the greatest number of flies occurred in the weeks ending July 27th and August 3rd; also that the deaths from intestinal diseases rose above the normal at the same time at which flies became prevalent, culminated at the same high point, and fell off with slight lag at the time of the gradual falling off of the prevalence of the insects.

Similar studies have been carried on during the summer of 1908 in the city of Washington, and the curve of typhoid-fly abundance for the whole city, as well as that for a district comprising eight city squares in which intensive studies have been made both of flies and of disease, will be plotted at the close of the season. At the time of present writing this work has not been completed.

The typhoid fly also possesses importance as a disseminator of the bacilli of tuberculosis. In a paper by Dr. Frederick T. Lord, of Boston, reprinted from the Boston Medical and Surgical Journal for December 15th, 1904, pages 651-654, the following conclusions are reached:

"1. Flies may ingest tubercular sputum and excrete tubercle bacilli, the virulence of which may last for at least fifteen days.

"2. The danger of human infection from tubercular flyspecks is by the ingestion of the specks on food. Spontaneous liberation of tubercle bacilli from flyspecks is unlikely. If mechanically disturbed, infection of the surrounding air may occur.

"As a corollary to these conclusions, it is suggested that—

"3. Tubercular material (sputum, pus from discharging sinuses, fecal matter from patients with intestinal tuberculosis, etc.) should be carefully protected from flies, lest they act as disseminators of the tubercle bacilli.

"4. During the fly season greater attention should be paid to the screening of rooms and hospital wards containing patients with tuberculosis, and laboratories where tubercular material is examined.

"5. As these precautions would not eliminate fly infection by patients at large, foodstuffs should be protected from flies which may already have ingested tubercular material."

From all these facts it appears that the most important part played by the typhoid fly or house fly in the human economy is to carry bacteria from one place to another. The following table and comments are taken from Bulletin No. 51 (April, 1908) of the Storrs Agricultural Experiment Station, Storrs, Conn., entitled "Sources of Bacteria in Milk," by W. M. Esten and C. J. Mason:

"From the above table the bacterial population of 414 flies is pretty well represented. The domestic fly is passing from a disgusting nuisance and troublesome pest to a reputation of being a dangerous enemy to human health. A species of mosquito has been demonstrated to be the cause of the spread of malaria. Another kind of mosquito is the cause of yellow fever, and now the house fly is considered an agency in the distribution of typhoid fever, summer complaint, cholera infantum, etc.

"The numbers of bacteria on a single fly may range all the way from 550 to 6,600,000. Early in the fly season the numbers of bacteria on flies are comparatively small, while later the numbers are comparatively very large. The place where flies live also determines largely the numbers that they carry. The average for the 414 flies was about one and one-fourth million bacteria on each. It hardly seems possible for so small a bit of life to carry so large a number of organisms. The method of the experiment was to catch the flies from the several sources by means of a sterile fly net, introduce them into a sterile bottle, and pour into the bottle a known quantity of sterilized water, then shake the bottle to wash the bacteria from their bodies, to simulate the number of organisms that would come from a fly in falling into a lot of milk. In experiments *d*, *e*, and *f* the bacteria were analyzed into four groups. The objectionable class, *coli-ærogenes* type, was two and one-half times as abundant as the favorable acid type. If these flies stayed in the pigpen vicinity there would be less objection to the flies and the kinds of organisms they carry, but the fly is a migratory insect and it visits everything 'under the sun.' It is almost impossible to keep it out of our kitchens, dining rooms, cow stables, and milk rooms. The only remedy for this rather serious condition of things is, remove the pigpen as far as possible from the dairy and dwelling house. Extreme care should be taken in keeping flies out of the cow stable, milk rooms, and dwellings. Flies walking over our food are the cause of one of the worst contaminations that could occur from the standpoint of cleanliness and the danger of distributing disease germs."

The danger of the typhoid or house fly in the carriage of disease has thus been abundantly demonstrated. Further than this, it is an intolerable nuisance. With mosquitoes it necessitates an annual outlay for window and door screens in the United States of not less than ten millions of dollars. As a carrier of disease it causes a loss of many millions of dollars annually. Dr. G. N. Kober, in a paper prepared for the Governors' Conference on the Conservation of Natural Resources, held at the White House in May, 1908, entitled "The Conservation of Life and Health by Improved Water Supply," presented figures showing that the decrease in the vital assets of the country through typhoid fever in a single year is more than $350,000,000. The house fly, as an important agent in the spread of this disease, is responsible for a very considerable portion of this decrease in vital assets. As an agency in the spread of other intestinal diseases, this sum must be greatly increased, and yet it is allowed to breed unrestricted all over the United States; it is allowed to enter freely the houses of the great majority of our people; it is allowed to spread bacteria freely over our food supplies in the markets and in the kitchens and dining rooms of private houses, and, to use the happy phraseology of Dr. Theobald Smith, "when we go into public restaurants in midsummer we are compelled to fight for our food with the myriads of house flies which we find there alert, persistent, and invincible."

Even if the typhoid or house fly were a creature difficult to destroy, the general failure on the part of communities to make any efforts whatever to reduce its numbers could properly be termed criminal neglect; but since, as will be shown, it is comparatively an easy matter to do away with the plague of flies, this neglect becomes an evidence of ignorance or of a carelessness in regard to disease-producing filth which to the informed mind constitutes a serious blot on civilized methods of life.

Strange as it may seem, an exhaustive study of the conditions which produce house flies in numbers has never been made. The life history of the insect in general was, down to 1873, mentioned in only three European works and few exact facts were given. In 1873 Dr. A. S. Packard, then of Salem, Mass., studied the transformations of the insect and gave descriptions of all stages, showing that the growth of a generation from the egg state to the adult occupies from 10 to 14 days.

In 1895 the writer traced the life history in question, indicating that 120 eggs are laid by a single female, and that in Washington, in midsummer, a generation is produced every ten days. Although numerous substances were experimented with, he was able to breed the fly only in horse manure. Later investigations indicated that the fly will breed in human excrement and in other fermenting vegetable and animal material, but that the vast majority of the flies that infest dwelling houses, both in cities and on farms, come from horse manure.

In 1907 careful investigations carried on in the city of Liverpool by Robert Newstead, lecturer in economic entomology and parasitology in the School of Tropical Medicine of the University of Liverpool, indicated that the chief breeding places of the house fly in that city should be classified under the following heads:

(1) Middensteads (places where dung is stored) containing horse manure only.

(2) Middensteads containing spent hops.

(3) Ash pits containing fermenting materials.

He found that the dung heaps of stables containing horse manure only were the chief breeding places. Where horse and cow manures were mixed the flies bred less numerously, and in barnyards where fowls were kept and allowed freedom relatively few of the house flies were found. Only one midden containing warm spent hops was inspected, and this was found to be as badly infested as any of the stable middens. A great deal of time was given to the inspection of ash pits, and it was found that wherever fermentation had taken place and artificial heat had been thus produced, such places were infested with house-fly larvæ and pupæ, often to the same alarming extent as in stable manure. Such ash pits as these almost invariably contained large quantities of old bedding or straw and paper, paper mixed with human excreta, or old rags, manure from rabbit hutches, etc., or a mixture of all these. About 25 per cent of the ash pits examined were thus infested, and house flies were found breeding in smaller numbers in ash pits in which no heat had been engendered by fermentation. The house fly was also found breeding by Mr. Newstead in certain temporary breeding places, such as collections of fermenting vegetable refuse, accumulations of manure at the wharves, and in bedding in poultry pen.

Still more recent investigations were carried on during 1908 by Prof. S. A. Forbes, State entomologist of Illinois, who has reared it in large numbers from the contents of paunches of slaughtered cattle, from refuse hog hairs, from tallow vats, from carcasses of various animals, miscellaneous garbage, and so on.

All this means that if we allow the accumulation of filth we will have house flies, and if we do not allow it to accumulate we will have no house flies. With the careful collection of garbage in cans and the removal of the contents at more frequent intervals than ten days, and with the proper regulation of abattoirs, and more particularly with the proper regulation of stables in which horses are kept, the typhoid fly will become a rare species. It will not be necessary to treat horse manure with chloride of lime or with kerosene or with a solution of Paris green or arsenate of lead, if stable men are required to place the manure daily in a properly covered receptacle and if it is carried away once a week.

We have thus shown that the typhoid or house fly is a general and common carrier of pathogenic bacteria. It may carry typhoid fever, Asiatic cholera, dysentery, cholera morbus, and other intestinal diseases; it may carry the bacilli of tuberculosis and certain eye diseases; it is everywhere present, and it is disposed of with comparative ease. It is the duty of every individual to guard so far as possible against the occurrence of flies upon his premises. It is the duty of every community, through its board of health, to spend money in the warfare against this enemy of mankind. This duty is as pronounced as though the community were attacked by bands of ravenous wolves.

Litho marlite, a marble-like, artificial stone, is produced by mixing 15 parts of water, ¼ part of glue water and ¼ part of powdered borax, with so much gypsum that a paste suitable for molding is obtained. By stirring in coloring substances, the resemblance to marble may be increased.

PRINCIPLES OF FAULT LOCATION.*

THE USE OF WHEATSTONE TESTING INSTRUMENTS

BY JULIUS BERNSTEIN.

In presenting this paper on fault location, the subject will be treated in a general way, with the hope that those who are not familiar with the principles upon which are based some of the ordinary measurements for the location of faults will recognize that these fundamental principles are quite simple and are easily understood.

My remarks, which are based upon the methods of telephone practice, will be confined to the use of those testing instruments which are based upon the principle of the Wheatstone bridge, inasmuch as practically all faults can be located by the "loop" methods, which are particular cases of the Wheatstone bridge. While it is possible easily to determine the nature of a fault by simple tests and, with a good knowledge of line conditions, an experienced tester can often approximate the distance to a fault, it is always desirable to make an exact location with a testing set, in order that every facility may be afforded in finding and clearing the trouble in the shortest possible time. The voltmeter can be used for some tests, but at their best, these are rough, and are not to be recommended except where instruments for the more reliable tests are lacking.

WHEATSTONE BRIDGE.

Our first consideration will be an explanation of the Wheatstone bridge. The system of conductors called the Wheatstone bridge, is the most common of the several arrangements for measuring resistances, and is represented by the familiar conventional diagram shown in Fig. 1.

The current from the battery is made to branch into two paths at c and reunite at d, so that part of the current flows through the points e and f. A, B, X, and R are known as the arms of the bridge, although in

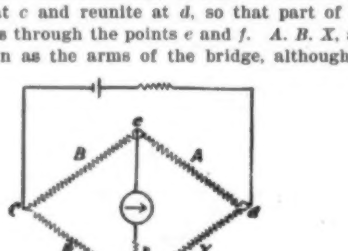


FIG. 1.—DIAGRAM SHOWING PRINCIPLE OF WHEATSTONE BRIDGE.

practice A and B are termed the "bridge arms" or "ratio arms," R the "rheostat," and X the "unknown resistance." When the galvanometer shows no deflection, it becomes evident that the two points e and f are at equi-potential, since current flow can only be the result of potential difference.

The bridge is said to be balanced, and the resistances in the arms will then have relation to each other as expressed in the simple proportion,

$$\frac{A}{B} = \frac{X}{R} \text{ or } A \times R = B \times X.$$

From the foregoing simple proportions, it is apparent that, by knowing the values of three arms of the bridge, the fourth can be quickly calculated, or

$$X = \frac{A}{B} R$$

It is to be noted that any resistances in the galvanometer r or battery r' circuits do not affect the values or ratios of the bridge arms. It is also to be noted that the position of the galvanometer and battery may be interchanged without in any way affecting the law of the bridge.

The Wheatstone bridge would have a restricted range of measurement if the arms were equal. It will be evident that the adjustable resistance will represent the total amount of the unknown resistance that can be measured under conditions of equal bridge arms. By altering the ratio of the arms of the bridge we can measure very high or very low resistances. This is accomplished in an actual bridge by placing in the arms A and B resistances having values of at least 1, 10, 100, 1,000 ohms, and at times 10,000 ohms.

If the unknown resistance is equal to the ratio $\frac{A}{B}$ multiplied by the resistance in the rheostat to balance, it is evident that when measuring small resistances, maximum accuracy will be had by making A small and B large, as this will mean a division for the value of the rheostat. If, for instance, we make A 1 ohm, and B 1,000 ohms, and the rheostat value was 67, the unknown resistance would be 0.067 ohm. If we were concerned with measuring a large resistance, we would place a larger value in A and a small one in B. If A were made 1,000 ohms, and B 1 ohm, and the rheostat

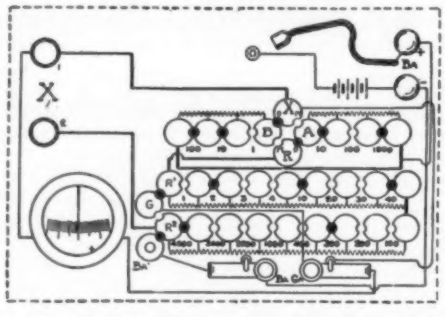


FIG. 2.—DIAGRAM OF CONNECTIONS, POST-OFFICE WHEATSTONE BRIDGE.

value was 67, the unknown resistance would be 67,000 ohms.

Having thus familiarized ourselves with the basic principles of the Wheatstone bridge, we will turn our attention to a modification of the Wheatstone bridge, called the slide-wire bridge.

Referring again to Fig. 1, we can reason that it is not necessary to know the actual values of the resistances in arms A and B to determine X, if we know their ratio. Our assumption is that when the bridge is balanced, the voltage drop over A equals that over X, and the drop over B equals that over R, consequently if the parts A and B consist of a straight wire with provision so that one terminal of the galvanometer can be moved along it for a balance, then the proportional parts of the wire on each side of the balance point can be used for the ratio $\frac{A}{B}$.

It can be looked upon as being a Wheatstone bridge, in which the bridge arms are varied to obtain a balance, and the rheostat has one fixed value for any particular measurement. Since the value of the unknown resistance is determined in terms of the rheostat by the ratio of the bridge arms to each other, it is immaterial whether we express the ratio in ohms, or in length of wire.

TESTING SETS.

The term "portable testing set" is usually understood to mean some form of Wheatstone bridge, complete with galvanometer and battery, mounted in a carrying case, and arranged for the various tests to which a bridge can be put. There are two types in general use, namely, the plug and dial. In the plug type the resistances are inserted in the circuit by

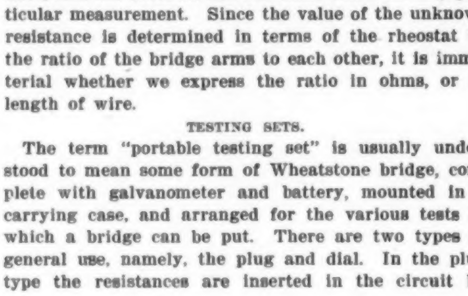


FIG. 3.—CIRCUITS OF DECADE TYPE OF WHEATSTONE BRIDGE.

manipulating plugs, and in the latter switches or dials are utilized. A superficial examination of these instruments will not show the relation of the arms, as we have previously discussed them, if one expected to see the same geometrical forms as indicated in the diagrams. An examination of the circuit, however, will reveal the same connections as we saw in the theoretical arrangement. Fig. 2 shows the connections for a post office Wheatstone bridge (a form of testing set often met with in practice).

The manipulation of the bridge is quite simple. The resistance to be measured is connected between the posts marked X and after setting the plugs or switches for measuring resistance as distinguished from fault location, and as given in the directions for using a particular instrument, the rheostat is adjusted until a balance is obtained as indicated by no deflection of the galvanometer. The use of the proper values in the bridge arms, in order to get best results for any measurement, is provided for by a table which usually accompanies it.

The instruments constructed on the plug principle are of the post office pattern or "plug-out" method, and the decade or "plug-in" pattern (Fig. 3). The name "post office bridge" is derived from the fact that the general construction was first gotten out by the Department of Telegraphs of the English government, which is under the supervision of the post office. This type is rapidly falling into disuse, due to several objectionable features in the manipulation of the plugs. The plugs are close fitting, which prevents convenience of manipulation. The plugs can be easily mislaid or lost. Another objection is the loosening of an adjacent plug when its neighbor is removed, and which often places a variable resistance in the circuit. In summing up the total resistance in the rheostat, it is necessary to add up a number of odd values, which can readily be a source of error.

The decade plan of resistances has the following special advantages:

A single plug only is required for each row of resistances, which makes it very convenient to manipulate. The resistances are read directly from the position of the plugs. The contact blocks are in pairs, and each pair is mechanically independent of the other blocks. There is consequently no danger that a plug contact will be loosened by removing a plug near it.

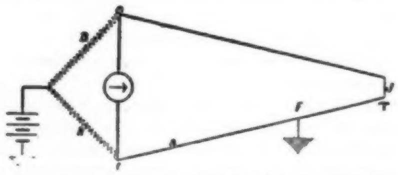


FIG. 4.—THE MURRAY LOOP TEST.

This is a trouble which must be guarded against in using the rheostats having the 1, 2, 3, 4 arrangement, or the 1, 2, 2, 5 arrangement, by running over all of the plugs to see that they are tightly in position just before making a measurement. On account of the ample distance between the rows, there is no trouble in manipulating the plugs, even when the operator's hands become benumbed by cold or he has to wear gloves.

The dial form of bridge has some advantages over the decade plan, but for all practical purposes, the selection of one type or the other is wholly one of choice.

Portable testing sets on the slide-wire principle do not permit all measurements of resistance to be made to the same degree of accuracy as with the previous types of bridges discussed. They have the advantage of simplicity of manipulation and are to be recommended when the fault location is to be done by those who are not experienced with the more complex bridge arrangements, or when conditions do not require maximum accuracy. In many makes of this instrument the manufacturers use straight stretched wires, as it is necessary to have a sufficiently long wire to give accuracy of setting. These wires are, however, objectionable on account of their liability to break where soldered, and their use makes an awkward hand stylus necessary for touching the wires.

CLASSES OF FAULTS.

Before considering any diagrams, some general remarks will be in order. The term fault is intended to cover every variety of damage by which the electrical efficiency of a line is affected. Defects which impair the mechanical condition of the line, without affecting it electrically, do not come under the heading. An aerial wire may be penetrated by rust, or a cable sheath may be damaged, without a trace of change in the electrical condition of the line.

The different kinds of faults may be distinguished by the following classification:

Grounds are defective insulation, to ground or to a cable sheath.

Crosses are defective insulation between wires.

* A condensation of a paper read before the International Association of Municipal Electricians, Detroit.

Opens are breaks in the conductor, so that two parts are entirely separated electrically.

Inductive crosses result from the transposition of single sides of adjacent pairs.

In speaking of crosses or grounds, it is well to use the modifiers "total" or "dead" and "partial," as a dead ground and a partial cross.

The first step in fault testing is to ascertain the nature of the fault and to give some particular study to the line in trouble by reviewing your knowledge of the line conditions. Having decided whether it is an open, a cross, or a ground, the next procedure is to make a location. The Wheatstone bridge is employed for locating a cross or ground by the "loop tests," and so called because it is necessary to have a complete circuit from one binding post of the instrument through the faulty section of the line and back to the other binding post of the instrument. The circuit is called the loop. The different sections forming the loop need not be of the same sectional area; it is only necessary that there be two independent paths of good insulation from the testing point to the fault. The simplest way to get this loop is to use the mate of the faulty wire, if the wires are in a cable; or, if the wire is an aerial or single conductor in a cable, then we must use an external conductor for a return.

THE MURRAY LOOP TEST.

Referring now to Fig. 4, which represents the connections for the Murray loop, at first inspection we will see an arrangement of conductors exactly like that of the Wheatstone bridge. The wire f T has a fault at F, and is looped to a good wire at J. The loop is connected to the testing set at e and f. The resistances B and R are in the instrument, and form two arms of the bridge, while the section f F of the faulty wire, and the remaining portion of the loop F e, form the other two arms of the bridge. The galvanometer and battery are connected as shown. The current from the battery flows through the earth from the point of grounding at the testing set to the fault. This connection is independent of the resistances forming the bridge, as far as its own resistance is concerned. The earth has a negligible resistance, and while the fault will generally have some resistance, unless it be

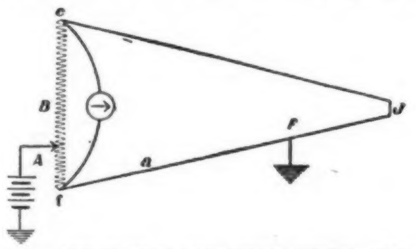


FIG. 5.—MURRAY LOOP TEST WITH SLIDE WIRE BRIDGE.

a dead ground or cross, its resistance corresponds to r' of Fig. 1. Calling a the resistance of the wire from f to F, or the resistance from the instrument to the fault, and r the total resistance of the loop, from the law of the Wheatstone bridge we have:

$$\frac{B}{R}=\frac{r-a}{a} \text{ and } a=\frac{Rr}{B+R}$$

From the last equation, the distance to the fault may be readily calculated when the values of B and R and the resistances per unit length of the loop wires are known.

Since in uniform wires the resistance is proportional to the length, these equations may also be written, when all the wire of the loop is of one size:

$$\frac{B}{R}=\frac{L-d}{d} \text{ and } d=\frac{RL}{B+R}$$

where L is the total length of the loop, and d is the distance to the fault. This formula should always be used when it is applicable, as it is the most accurate as well as the most convenient. In using the previous formula, in order to calculate the distance to the fault, the resistance of the wire per 1,000 feet must be determined from a wire table. A slight variation from gage or a difference of temperature from that assumed may cause a considerable error. Errors from these sources are very largely eliminated when the distance to the fault is determined as a fraction of the length of the loop.

In using a bridge for locating by the Murray loop, it is customary to use a 10,000-ohm coil for arm B, and vary the rheostat until a balance is obtained. This operation, while quite simple, can be made more rapid when using testing sets built upon the slide-wire principle. In using an instrument of this kind, there are limitations in its range, but in its own field of usefulness it is to be strongly recommended.

Referring to Fig. 5, a circuit will be noted arranged similar to that of the slide-wire bridge. A contact can be moved along a uniform resistance, and the ratio is that of the two parts of wire on each side of the contact. Let r equal the total resistance of the loop, and a the resistance from the instrument to the fault, then the formula for solving becomes quite simple, and is:

$$\frac{A}{B}=\frac{a}{r-a} \text{ from which } a=\frac{Ar}{1{,}000}$$

Another way of analyzing this case is to note the symmetry of the arrangement as indicated in Fig. 5.

It is apparent that if the bridge is balanced with the contact half way between e and f, then the arm f J must equal e J, since A and B are equal, which implies from the law of the bridge that the other two arms must have the same ratio to each other. As the arm B increases and A decreases, so does the distance

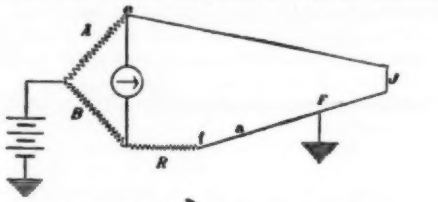


FIG. 6.—THE VARLEY LOOP TEST.

or resistance from e to F increase, and the distance or resistance f F decrease. Since in uniform wires the resistance is proportional to the length, this formula may be written:

$$\frac{A}{1{,}000-A}=\frac{d}{L-d} \text{ and } d=\frac{A}{1{,}000}L$$

where L is the total length of the loop, and d is the distance to the fault from f. The last formula is the most convenient, but it is only applicable when the wires have the same resistance per unit length.

THE VARLEY LOOP TEST.

The Varley loop test differs from the Murray in having a portion of the loop made up of resistance in the testing set, as shown in Fig. 6. The Varley test can be most usefully applied in those types of bridges which permit of making the ratio of A to B unity, or 10, 100, 1,000, etc. In these cases the ratio of A to B is fixed and R is varied until a balance is effected. Calling r the resistance of the faulty wire f J plus that of the wire e J and a, the resistance from f to the fault, we have:

$$\frac{A}{B}=\frac{r-a}{R+a} \text{ and } a=\frac{Br-AR}{A+B}$$

The formula for the Varley loop admits of several modifications, which will not be given at this time, for lack of space.

If the fault in a grounded or crossed conductor were always of practically infinitely low resistance—that is to say, if it were a "dead" ground or short-circuit—its location could easily be detected by measuring the resistance from the point of test, and back again through the ground, or through the other conductor affected by a regular resistance test. Unfortunately, however, it is seldom the case that this condition exists, and tests giving results independent of the resistance of the return circuits and at the point of trouble are therefore necessary.

The loop tests, you will note, fulfill these requirements. The only effect a high resistance will have upon our test will be to reduce the electro-motive force of the battery, so that in very high resistance faults it becomes necessary to employ 50 and 100 cells, so as

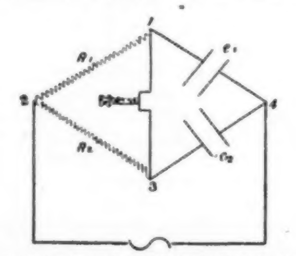


FIG. 7.—CAPACITY RESISTANCE BRIDGE.

to impress the electromotive force through the fault, so that the galvanometer will have sufficient sensibility.

THE LOCATION OF OPENS.

When a conductor is actually broken and there is no return circuit from the brake, a new set of conditions must be considered. In locating the break, we depend upon the fact that every conductor, whether it is in a cable in the earth or submerged in water, or is an air wire, possesses "capacity" and is in fact a condenser. The conductor itself forms one plate, the insulation from the point of test to the break the dielectric, while the other plate is the earth, water or lead sheath.

This capacity is generally proportional to the length of the conductor, so if we know its capacity per unit length, and measure the capacity up to the break, we can calculate the length of the conductor to the break. This method is open to the objection that the capacity cannot always be relied upon as uniform throughout the length of the wire, variations of 10 per cent or more often occurring. In measuring the capacity by this test, the deflection method is used, in which the cable is charged to a certain potential, and the discharge is then read by means of a deflecting galvanometer. The deflection, however, is liable to be augmented through the action of what is called "electrical absorption," which produces return currents after the true discharge of the condenser capacity is over. This phenomenon takes place to greater or less extent with all cables, and increases with rise of temperature.

A method which largely removes the above objections, and at the same time can be performed by a simple bridge arrangement, with the addition of a telephone receiver and reversed battery current, is to compare the capacity of the open wire, from the point of test to the open, with the capacity of the good mate of known length.

Referring to Fig. 7, if the capacities of C_1 and C_2 (represented by the conventional symbol of parallel lines) are the capacities of an open wire and its good mate, respectively, we can balance the two capacities against R_1 and R_2 in the other two arms of a Wheatstone bridge. Instead of a galvanometer and battery, a telephone and a source of alternating current are shown in Fig. 8. When the resistances are adjusted so that no sound is heard in the telephone, then the points 1 and 3 are equal in potential. The cable capacities represented by C_1 and C_2 are then charged to the same difference of potential and contain quantities of electricity proportional to their capacities; but the quantities flowing into the condensers in the same time are inversely proportional to the resistances R_1 and R_2; therefore,

$$\frac{R_2}{R_1}=\frac{C_1}{C_2}$$

Since the good and bad wires are under similar conditions, their lengths may be taken as proportional to their capacities. Hence, if L_1 and L_2 represent the lengths of the bad and good wires, then

$$\frac{R_2}{R_1}=\frac{L_1}{L_2} \text{ or } L_1=\frac{R_2}{R_1}L_2$$

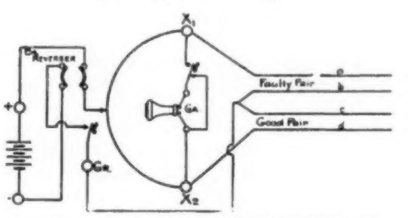


FIG. 8.—LOCATION OF "OPEN" BY COMPARISON OF CAPACITIES.

The question of allowance for lead wires does not enter, unless the leads are very long or a wire in a cable is used for a wire leading to the faulty cable.

Having thus become acquainted with the theory of the two loop methods, and the method for locating opens, we will consider some matters of a general character which must be observed, so that accuracy may attend your results.

In the use of testing apparatus, it is of primary importance that good electrical connections be made throughout the circuit. Attention must be paid to the cleanliness and the firm binding of all wires and leads. If one is to rely upon an inexperienced assistant for making joints and connections on poles and elsewhere, much annoyance may be experienced. This matter of good connections cannot be emphasized too much, as any resistance caused by poor connections in the loop circuit will enter directly as an error in the location. If, for instance, the assistant does not make a good connection in joining the good and faulty wires, but introduces a resistance of one-fourth ohm, where the wire is No. 22 B. & S. copper the location will be 16 feet in error. Proper care therefore will be immunity from many troublesome derangements and failures, the causes of which are usually discovered after much loss of time and labor.

FOREIGN CURRENTS.

A source of inconvenience and error lies in the fact that at the fault there may exist an electro-motive force due in some instances to the contact potential difference between the faulty conductor and that on which it is grounded. Not infrequently stray currents are flowing on your wires from light and power circuits, or are induced from such circuits. These currents are generally irregular and cause irregular deflections of the galvanometer. Where they occur, the battery should be made as large as possible, so that the galvanometer deflections due to the test current may be larger than those due to the stray current. If this precaution does not make it possible to make sufficiently accurate location, it may be necessary to make

use of another loop or postpone the test until conditions are more favorable.

A DISAPPEARING GROUND.

A disappearing ground is occasionally encountered while trying to locate a fault. This is generally caused by the battery current from the testing set turning a slight moisture ground into gas. Sometimes, by waiting for a short time, the ground will reappear. By employing more battery, so as to get a higher voltage, and taking a quick reading, it is sometimes possible to catch a location. It may be advisable in these cases to interchange the galvanometer and battery. When this is done the galvanometer current only flows through the fault, and it is much less likely to dissipate it than the battery current.

Sometimes the ground can be increased or permanently burned out by applying a ringing generator to the faulty wire. Before doing this, disconnect the testing apparatus.

If these methods are unsuccessful, it is best to leave the trouble until it becomes worse. A ground that is sufficient to make a line noisy, can, as a rule, be located.

INEQUALITIES IN LINE RESISTANCE.

All fault locations by loop methods are based on the assumption that the wires have a uniform resistance per unit length. This is never exactly true, and is sometimes very far from true. Unless the wire inequalities balance each other, which they do in many cases, the calculated location will be in error exactly in proportion to the inequalities. Among the causes of inequalities are introduced resistances such as poorly soldered sleeves, slight variations in gage, and inequalities in the temperature of different parts of the line. It is generally impossible to correct for these inequalities. In the cases of long lines, where there are considerable inequalities in temperature, the resulting resistance variations may be calculated and allowed for.

Another cause of inequality is unequal twisting of a wire in a cable. For this reason the loop should be made whenever possible by connecting the faulty wire to its mate, as the two will then be subject to the same conditions of twist, temperature, etc.

INCORRECT ASSUMPTION IN REGARD TO LINE RESISTANCE.

If calculations are based on resistances determined from the wire gage and wire tables, errors may occur, due to all of the causes mentioned in the preceding paragraph. This class of errors may be obviated by using the methods and formulæ which determine the distance to the fault as a fraction of the total length of the loop of the faulty wire. For this reason these methods are always to be preferred, when they are applicable. They are, however, only applicable when the good and faulty wires are the same length and gage.

On lines where a source of trouble is suspected as being due to poor joints, it is well to measure the resistance of the line from point to point, and compare the results with the correct resistance per unit length.

CORRECTION FOR LEAD WIRES.

It sometimes happens that the testing instrument cannot be placed directly at the cable ends, and it then becomes necessary to employ leading wires between the testing set and cable. When such is the case, it is simplest to use the leading wires of the same size as the faulty wire. Then the length of these leads must be added to L, the combined length of the good and the bad wires, and from the calculated distance to the fault must be subtracted the length of the leading wire connected to the faulty wire. If the leading wires are different in size from the cable wires, multiply the length of each of the former by its rated resistance per 1,000 feet and divide the product by the rated resistance per 1,000 feet of the size of wire in the cable. The values thus found represent the equivalent length of cable wire having a resistance equal to each leading wire.

If the resistance of each leading wire is known the equivalent length of the faulty wire having a resistance equal to each leading wire is found by dividing their respective resistances by the rated resistance per 1,000 feet of the faulty wire, multiplying the quotient by 1,000.

LEAD WIRE OF UNKNOWN RESISTANCE.

Occasionally it may be necessary to employ fixed leading wires whose separate resistances are unknown. The individual resistances of the wires may be obtained most easily by connecting them at the distant end and measuring the resistance of the loop. Then ground the connection and apply either the Murray or Varley loop test. This will give the proportion of the total loop resistance in each wire.

Before concluding the subject of the paper, some reference will be made to a few tests which are necessary as a preliminary to using the bridge for localization.

TESTS FOR OPENS.

To test for broken wires, the conductors should all be grounded at one end of the cable, and the test applied at the other end in the following manner: Ground one side of a battery to the lead cover of the cable and connect the other side to a galvanometer, voltmeter, electric bell or telephone receiver. The wire running from the other side of the instrument used should then be touched consecutively to every wire of the cable. No indication of an electric current is evidence that the wire under test is broken.

TEST FOR CROSSES.

In testing for crosses, bunch all the wires, and connect them to one end of a testing circuit, such as is described above; then remove, one by one, the wires bunched, touching each successively to the other end of the testing circuit. The indication of an electric current shows that the wire touched is crossed with one of the other wires; the wire should then be marked and connected to the bunch and the test repeated until nothing is left but crossed wires, when it is easy to determine between which wires the crosses exist; care must be taken to see that none of the wires are in contact with each other, or the lead cover at the far end of the cable.

Crossed wires are located by the same methods used for grounded wires, except that the binding post on the instrument, instead of being connected to ground, is usually connected to the wire crossed with the faulty wire. When this is not convenient ground the wire crossed on the faulty wire and connect the ground post to ground as usual.

TEST FOR GROUNDS.

Grounded wires may be detected in a cable by connecting a galvanometer in series with a battery, one pole of which is grounded. Connect the wires, one after another, to the other galvanometer terminal. A deflection shows a faulty wire.

This test can also be made with a telephone and direct-current magneto. The reversed-current magneto is not thoroughly reliable, because it will ring when the electrostatic capacity of the wire is sufficiently large. However, with it, in the hands of an experienced man, low-resistance faults can immediately be detected by the loudness of the ring and the resistance to rotation of the handle.

It is sometimes desirable to measure the resistance of the fault in order to determine how accurately a location may be made. This may be done by various methods. When the fault resistance is not high, it may be measured in the same way that conductor resistance is measured. When the fault resistance does not exceed 1,000 ohms, satisfactory locations can be made with a few cells of battery and the ordinary testing-set galvanometer. For higher resistances, additional battery will be required, and for very high resistance faults it is necessary to use a sensitive reflecting galvanometer.

Of importance equally as great as that of locating a fault after its occurrence, is to make systematic tests upon one's lines, so as to foretell the occurrence of such defects. The use of high-class insulated wires, both for overhead and underground cables, has increased to such an extent in recent years that I feel we are not realizing the importance of making systematic tests in order to maintain as high an efficiency as we should. This necessity of testing is especially true in the case of those who have charge of so vital a system as police and fire circuits.

SUBMARINE MINELAYERS.

One of the most interesting phases of the development of modern navies is the unceasing struggle which goes on between the instruments of attack and defense. Improvements in the resisting power of armor are followed by increased muzzle velocity and superior armor-piercing qualities of shells. Increased speed of vessels, enabling them to repel or evade the attacks of torpedo boats, is followed by an augmentation in the speed and range of the torpedo, and so *ad infinitum*, or, rather, *ad millennium*, when warships shall be no more. There is, however, one weapon—the submarine mine—which, from its comparative simplicity and the nature of its use, is not capable of much development, and yet is bound to assume increasing importance in modern naval warfare, if only for the reason that a mine is as well able to sink a "Dreadnought" or any possible or probable development thereof as a torpedo boat. It is quite evident that as the cost of our capital ships goes up the number we can afford to build will come down, and the greater the proportionate loss of a unit must become.

The destructive effect of a submarine mine is out of all proportion to its cost, and hence its increasing relative importance with the growth in size of the battleship. The mine, however, has its limitations. Apart from any considerations of international law, it cannot be sown broadcast over the ocean without being dangerous to friend and foe alike; but in the approaches to harbors, roadsteads, or possible landing places it may prove not only a valuable defense, but, as the Japanese showed at Port Arthur, a means of attack. The destruction of the Russian flagship, the "Petropavlovsk," by mines which had been laid in the fairway at the entrance to the harbor by the Japanese minelayer, "Koryo," under cover of the darkness in thick weather, is an instance of the damage which can be done with practically no risk to the attacking party. In this case the blow to the Russian fleet was most severe, and coming as it did so soon after the successful torpedo attack at the beginning of the war, when three battleships were disabled, the moral effect was such that no real attempt to act on the offensive was ever made by the Port Arthur fleet. This was fortunate for Admiral Togo, for with the possibility of the arrival of the Baltic fleet before him, he could not afford to risk trying conclusions in an open engagement between his battle fleet and the Russians, and his endeavor was to render them useless by corking the harbor, or by destroying them piecemeal by the agency of the torpedo or mine. The bottling process, as we know, proved abortive, but the torpedo and the mine served him in good stead.

The minelayer seems to have been an after-thought, for at the beginning of the war some mining operations appear to have been carried out by Togo's destroyers, a service for which they are not particularly suited, and which, in any case, takes them away from their legitimate business. One of the lessons of the naval operations before Port Arthur is that the provision of mine-laying vessels is as much a national need as the possession of submarines or any other of the various adjuncts or auxiliaries of a fleet. Their use need not be confined to the laying of minefields for the defense of our ports and arsenals; they can be employed with a blockading fleet, and, given suitable weather conditions for masking their operations, it is possible, as the Japanese showed, to place a mine-field at the entrance of a harbor so as to make a sortie by the vessels inside a movement dangerous to themselves. So far, we have done something toward the provision of mine-laying vessels by the conversion of two second-class cruisers of the "Apollo" type for this service, and provision for the conversion of four more is made in the current estimates; but it is open to question whether this has been real economy, as these vessels are much too big for the work. The laying of mines involves a certain amount of risk to the vessel carrying out the operation, as shown by the loss of the Russian mine transport, "Yenisei," and the smaller the vessel and the fewer the number of men required to work it the better, provided the essential qualifications are obtained. Speed is not an essential; but as for offensive operations it would be necessary to choose such weather conditions as would make interruption by torpedo attack improbable, it is essential that the mine-laying vessels be of sufficient size and seaworthiness to be able to work in almost any kind of weather; and further, as they may be called upon to operate in comparatively shallow water near land, they must be very handy and of such proportions and freeboard as to ride easily in a short, choppy, or confused sea. The type of vessel which immediately comes to the mind's eye when these conditions are reviewed is the North Sea trawler, and probably these boats would suit the purpose admirably with very little alteration. The cost of a fleet of half a dozen such vessels would be less than that of a single destroyer, and they would cost correspondingly less to maintain efficient and keep in commission. If specially designed for the work they might advantageously be fitted with internal combustion engines, as this type of machinery would take up less space than steam machinery and allow greater hold space for the carrying of mines; also by better fuel economy it would enable the minelayers to remain out of port for prolonged periods, with a consequent greater chance of their being on the spot at the psychological moment.

Until recently practice in mining was almost entirely carried out by large launches, which are only suitable for smooth-water conditions, and the provision of larger vessels has added considerably to the efficiency of the torpedo branch of the service. It is satisfactory to note from the First Lord's statement that the matter has received from the Admiralty the consideration which it deserves, and it would be a matter for regret if the present pressure for reduction of expenses resulted in the necessary action being put off till a "more convenient season."—The Engineer.

A new electric railroad is to cross the Alps and thus connect the canton of Grisons with Italy in the western part of Lombardy. The new line runs by way of Poschiavo pass to Tirano and from this point to Brescia, traversing Edolo on the route. The section from Brescia to Edolo is now in construction and will probably be finished before the end of this year. As regards the section from Edolo to Tirano, a concession for this line has been applied for from the Italian government by a Swiss construction firm, Busi et Cie. On the Swiss side, the work of building the electric road is now going on and is already well under way. This part of the line is known as the Bernina railroad, and it is expected that it will be opened for traffic during the summer of next year. In this way we obtain a direct route between the Grisons canton and the Italian railroad center of Brescia. Owing to the new railroad the international traffic between Switzerland and Italy will be facilitated.

A MEDIEVAL EDISON.

THE INGENIOUS MARQUIS OF WORCESTER.

BY GEORGE FREDERIC STRATTON.

IT has been said that Mr. Edison was the first inventor to develop an organized business of invention. The first available money which came into his hands was devoted to the building and equipment of workshops for purely experimental purposes, and since that time, his genius has been altogether engaged upon the practical development of his ideas. He has never engaged in business *per se*. But three hundred years ago a man was born in England who was nearly as persistent an inventor and investigator as Mr. Edison, and, apparently, almost as systematic. This was Edward Somerset, Marquis of Worcester.

It is a matter of no little wonderment that, in an age when mechanical pursuits were looked upon with great contempt by the class to which the marquis belonged, he should have shown such intense devotion to them. He was one of the wealthiest men in England. His ancestors had been soldiers and courtiers of great power and influence, and there was nothing in the early education or association of the marquis which was, in any degree, related to mechanical affairs; yet at the age of twenty-seven he had become so deeply interested in such matters, that he fitted up workshops at Raglan Castle, one of his homes, and engaged one Caspar Kalthoff, a clever artisan, as his chief workman. A few years later he moved these workshops to Vauxhall, near London, where he expended fifty thousand dollars in buildings and equipment, and a total of two hundred and fifty thousand dollars in experiments—sums which, considering the vast difference in money values between then and now, were really enormous. These experimental workshops he maintained through the whole of his life, broken, as it was, by the great rebellion against Charles the First, and the consequent civil war, in which the marquis was actively engaged. And so enthusiastic was he on scientific matters, so enlightened in his views, and so far ahead of his contemporaries in progressiveness, that he always expressed his determination to endow the extensive shops at Vauxhall, and, with them, found a college of artisans—a plan, however, which he was not able to carry out.

In 1663 he published a book entitled "A Century of Inventions." The full title is curious enough to be reprinted here:

"A Century of the names and Scantlings of such Inventions as at present I can call to mind to have tried and perfected which (my former notes being lost) I have, at the Instance of a Powerful Friend, endeavored now, in the year 1655 to set these down in such a Way as may sufficiently instruct me to put any of them in Practice."

The term "century" refers to the number of inventions described, and the book itself contains only what the author deemed the more important of his inventions, a great number having been omitted. The term "scantlings" means notes or very brief descriptions.

Among these one hundred inventions, many of them marvelously ingenious, are some which show that the marquis was fully two centuries ahead of his time. One of these, described in his own words, is "an engine, portable, in one's pocket, which may be carried and fastened on the inside of the greatest Ship, and at any appointed minute, though a week after, either of day or night, it shall irrevocably sink that ship."

Although the "Century of Inventions" is, for the most part, a catalogue only, and, except in a few cases, without description, the inventor left other papers which show many of his designs in detail, and from these we learn that this destructive "engine" was, practically, an explosive machine operated by clockwork. He supplements this invention by another. "A way from a mile off to dive and fasten a like Engine to any Ship so as it may punctually work the same effect, either for time or execution."

These seem to be the forerunners of the modern torpedo and submarine torpedo boat.

Another invention shows him to be the originator of safe-deposit doors and combination locks. His description reads:

"A way how a little triangle scrued key, not weighing a shilling, shall be capable and strong enough to bolt and unbolt round about a greate Door an hundred Bolts through fifty staples, two in each with a direct contrary motion and as many more from both sides and ends."

The combination lock is also described, as follows:

"An Escutchon to be placed before any of these locks with these properties:

"1. The owner (though a woman) may, with her delicate hand, vary the ways of coming to open the lock ten millions of times beyond the knowledge of the smith that made it, or of me who invented it. 2. If the stranger open it, it setteth an alarm a-going which the stranger cannot stop from running and, besides, though none be within hearing, yet it catcheth his hand as a Trap doth a Fox."

Here is the origin of one of the latest types of mud dredges:

"A Screw made like a water screw but the bottom made of Iron-plate, Spade-wise, which, at the side of a Boat emptieth the mud of a Pond or raiseth Gravel."

In one note he describes what he calls "an abundantly significant Seal," which is remarkably similar to a modern dating stamp, having adjustable seals in one frame, by which "the day of the Moneth, the day of the Week, the Moneth of the year, the Year of our Lord," and several other matters could be stamped, as desired.

He appears to have been the inventor of the hydraulic ram, for he describes a machine by which the force of a plunger in a pump may be used "to weigh up an anchor or to do any forcible exploit in the narrowest or lowest room in any Ship where few hands shall do the work of many."

In 1661 a patent was granted to him for an improved pistol, the specifications reading as follows: "To make certain guns or pistols which, in the tenth part of one minute, may with a flask contrived for that purpose, be recharged, the fourth part of one turn of the barrel, which remains still fixed, fastening it as forcibly and effectually as a dozen threads of any screw." In another manuscript this gun is described as one that "shall contain ten balls or pellets of lead, all the which shall go off one after another, having once given fire, so that with one harquibus one may kill ten thieves without recharging." Although no fuller description is extant, it seems very clear that this was a magazine gun, with breechloading arrangement.

In another passage he claims to have devised a universal alphabet: "How to compose an Universal Character, methodical and easie to be written, yet intelligible in any language; so that, if an Englishman write it in English, a Frenchman, Italian, Spaniard, Irish, Welsh, being scholars, shall as perfectly understand it in their own tongue as if they were perfect English."

These inventions, it must be remembered, were made in an age when a machine, as understood in these days, was unknown. Hand tools were of the crudest description, and a combination which formed the simplest machine was looked upon with incredulity and often denounced as pertaining to "Black Art."

The last invention described in the marquis's book is the "Fire Water Work," as he calls it in one place, and the "Water-Commanding Engine" in another. He built one of these engines at Raglan Castle and another at Vauxhall, both of which were used for raising water to cisterns on the roof, a drive of about forty feet; that at Vauxhall being kept in operation for over eight years. Although these engines were operated by steam, they did not resemble the simple piston engine of the present time, but they were the first machines ever devised for the practical utilization of the power of steam. Simple and crude as they were, they demonstrated, as never before had been demonstrated, the possibility of a power which would revolutionize the industrial and even social conditions of the world. The marquis himself undoubtedly foresaw these possibilities. He says: "I may boldly call it the Most Stupendous Work in the whole world . . . . I deem this Invention to Crown my Labours, to reward my Expenses and make my Thoughts acquiesce in way of further Inventions." And in another place he says: "I call this a *Semi-Omnipotent Engine*, and do intend that a model, thereof, be burried with me." These engines excited great interest among the few scientific men of the day, but all others looked upon them with the greatest suspicion and ridicule. In fact, after the death of the marquis, his wife, who was as enthusiastic over their possibilities as he had been, was roundly denounced, by the priests, for her persistent attempts to obtain assistance for putting them into public use. A letter to her from one of these priests contains these words:

"It is a great temptation which you are now under, and very dangerous and hurtful, both to your temporal and eternall happiness; yett, I confess, that the Devil to make his suggestions the more prevalent, doth make use of some motives that seeme plausible."

Those were not the days of the promoter and the business organizer, and a century and a half elapsed before this invention of the marquis found its development in the hands of Watt, Newcomen, and Stephenson.

The marquis lived in the most troubled times of English history—the time of Charles the First, the civil war, and the doughty, imperious Cromwell. He was a staunch royalist, and spent no less than three hundred and fifty thousand pounds in equipping troops and fighting for his royal master.

After the king's execution and the accession of Cromwell to the Protectorate, Worcester's estates were confiscated, and he was exiled; going to France, where he lived for three years in great poverty. Returning to England, he was seized and imprisoned in the Tower of London, where he remained for another three years; and his intense devotion to scientific and mechanical experimentation is shown by the fact that, during that period of exile, imprisonment, and dire poverty, he still sent to his chief craftsman Kalthoff (who had been permitted by Cromwell to continue his work at Vauxhall) drawings and instructions for making models of such inventions as continually occupied his mind.

The marquis was scarcely a philosopher. There were men generations before him, and of his own time, as well as of succeeding times, whose names are famous for their deep speculations upon natural phenomena; but he was the first great practical inventor; and in view of the times and conditions under which he worked, in view of the fact that many of the great inventions of modern days, viz., the steam engine, the revolver, the hydraulic ram, the dredge, the combination lock, and other things, had some measure of practical suggestion, at least, from his great and versatile brain, it can scarcely be said of him that he was surpassed by any man in ingenuity, versatility, or devotion to mechanical invention, until the arrival of Edison.

An old biographer of his has said that "he took nothing on trust, but reduced everything to the test of absolute experiment. There never was any contrivance of which he thought or read, that he did not reduce to a model." Two hundred and fifty years after him the Wizard of Menlo Park made a similar remark regarding himself: "I never take anything for granted. I can't recall a single problem in my life, of any sort, that I ever started on which I didn't solve, or prove that it couldn't be solved." A kindred spirit surely, showing indisputably that the ambitions and methods of the greatest inventor of the middle ages were the same as those of the greatest inventor of modern times. But how widely different in their successes! One has acquired unbounded honor, wealth, and fame; the other died in poverty, his inventions viewed with incredulous ridicule.

The lives of inventors abound in dramatic stories of difficulty, failure, and bitterness, but nowhere is there found anything more pathetic than the last appeal for assistance, from the House of Lords, by this gallant old soldier and gentleman, broken in health and fortune and vainly seeking some little return from his inventions. He says: "The more, then, that you shall be pleased to make use of my inventions, the more inventive shall you find me—one invention begetting another. . . . Ingeniously confessing that the melancholy which hath lately seized upon me (the cause whereof none of you but may easily guess) hath, I dare say, retarded more advantages to the public service than modesty will permit me to utter."

A few weeks afterward he died, but whether or not a model of his beloved "Semi-Omnipotent Engine" was buried with him history does not state.

M. Gustave Lyon has discovered a method of remedying faults in the acoustic properties of large halls, and his idea is the result of a long series of researches. It will be of great benefit in many cases, and he has just made a practical application of it in the great hall of the Trocadero, one of the largest in Paris, which is notorious for its acoustic defects, as the echo is such that it is almost impossible to hear a speaker in some parts of the hall. The worst spot is at the president's box. Lyon uses a very ingenious method of locating the surfaces which give the echos, and then covers them by a double cloth covering spaced a few inches apart. A single cloth will not deaden the echo, but he discovered that a double cloth would do so. Just why is not as yet clear, but the fact remains that the Trocadero hall is wonderfully improved.

THE RAVAUD AERO-HYDROPLANE.

A NEW TYPE OF AEROPLANE ADAPTED TO RISE FROM WATER.

LAST year some dwellers on the banks of the river Marne were agreeably surprised to see traveling on land or water, at the will of the steersman, a strange boat with wheels, which was christened the "amphibious autoboat."

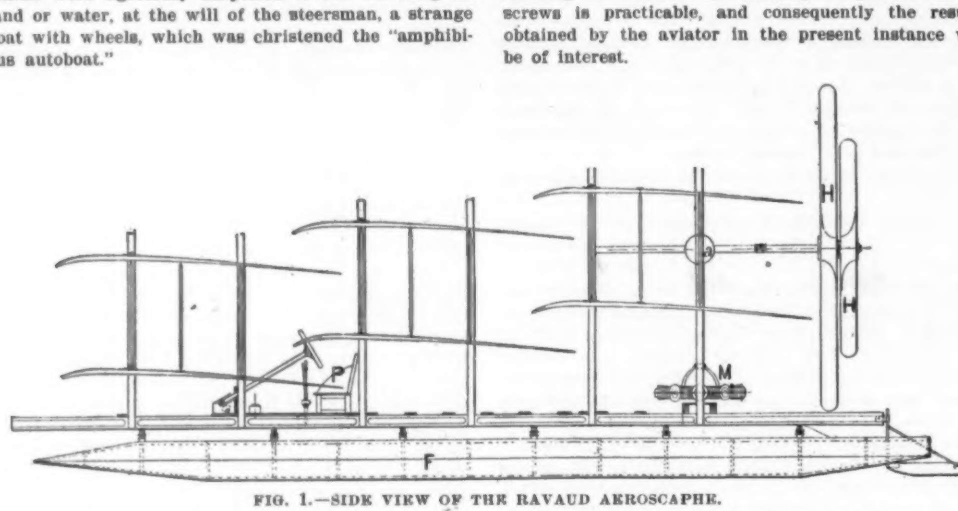


FIG. 1.—SIDE VIEW OF THE RAVAUD AEROSCAPHE.

M, Gnôme 50-horse-power revolving-cylinder motor; H H, screw propellers; F, floats; P, pilot's seat; a, case inclosing bevel gears.

But now, following on the developments in aviation and motor boats, M. Ravaud has just had constructed an aeroplane with floats attached, which he calls "aeroscaphe."

However, the name of his machine, "aeroscaphe," is not new. Perhaps, in adopting it, he has remembered the great anti-balloonist agitation of 1863-4 and the aeroscaphes of that same period made by M. Charvin's company.

M. Ravaud's apparatus was entered at the Monaco meeting under the name of "motoscaphe." Two names are not too many by which to designate this original apparatus, since it must float on the water and travel through space, conquering the air. The aero-hydroplane, the aeroscaphe, or the motoscaphe must then possess the qualities of a heavier-than-air flying machine and also of a hydroplane boat.

Following are the plans that have been drawn up to permit of these two functions:

This aeroplane, which was designed and constructed at the works of M. L. Chauvière, with the assistance and co-operation of Messrs. Morel and Baduel, engineers, is made of 15 planes of 2.50 meters by 1 meter (8.20 by 3.28 feet) in size, representing a total surface of 37.50 square meters (403.65 square feet). The illustrations show the arrangement of the planes and also of the propellers.

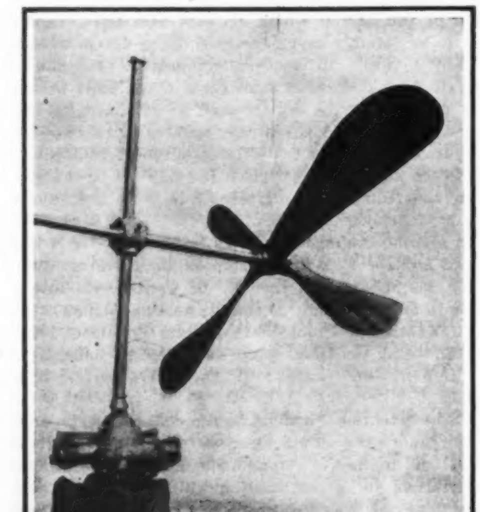
By a special arrangement the planes can be tipped to the right or to the left of the central part on which the pilot stands. The front view (Fig. 2) shows in dotted lines the inclinations of the planes.

While in normal motion, the planes keep a natural position, as at E, the position E' being taken according as the pilot wishes to descend to one side or the other, or to turn round.

Two wooden propellers, 8.2 and 10.5 feet in diameter respectively, are placed at the rear and keyed on concentric shafts. They turn in opposite directions at the rate of about 600 revolutions per minute.

These screws are arranged so that they can steer the apparatus. For this purpose their shafts are capable of moving in a horizontal plane some 20 degrees (10 degrees on each side of the longitudinal axis). There is some doubt as to whether this method of steering the machine by changing the position of the screws is practicable, and consequently the results obtained by the aviator in the present instance will be of interest.

The two propellers are driven by a Gnôme revolving cylinder motor, a description of which will be found in SUPPLEMENT No. 1729. The motor is shown at M in the diagram. It revolves horizontally, and drives



POWER PLANT AND PROPELLERS OF THE AEROSCAPHE.

A Gnôme revolving-cylinder motor drives the propellers in opposite directions through bevel gears. The concentric propeller shafts can be swung to one side or the other in order to steer the aeroplane.

the hollow vertical shaft, which in turn drives two propeller shafts by bevel gears shown incased at a. This motor has seven cylinders forming a star; it develops 50 horse-power at 1,200 revolutions a minute, and weighs about 80 kilogrammes (176 pounds). The bore and stroke are 110 and 120 millimeters (4.33 x 4.72 inches) respectively.

The pilot, placed at P, has in front of him the steering wheel, which moves the propeller shaft to the right or left. He has beside him also three levers, one to alter the incidence of the front planes, another

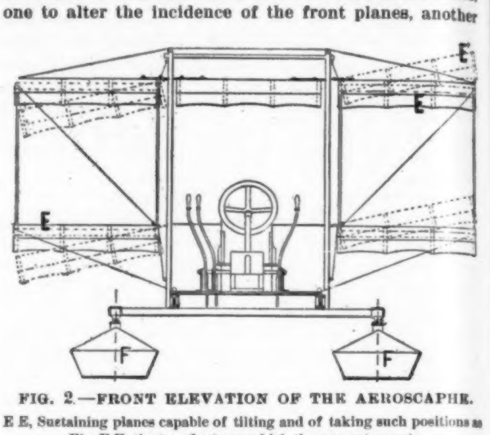


FIG. 2.—FRONT ELEVATION OF THE AEROSCAPHE.

E E, Sustaining planes capable of tilting and of taking such positions as E'; F F, the two floats on which the apparatus rests.

the incidence of the rear planes, and a third for working the three groups of planes.

As can be seen from our illustrations, the aeroscaphe has neither launching wheels nor skids.

By means of cross pieces, the superstructure rests on two floats of special shape, F F, made of wood and covered with canvas.

These floats have been estimated not to exceed a draft of 7 to 8 centimeters (2¾ to 3 inches). Their shape is such as to offer the least resistance to forward motion.

The weight of the complete machine is 450 to 500 kilogrammes (992 to 1,102 pounds).

The above are the main characteristics of the Ravaud aeroscaphe. It is doubtful whether any new records will be made with it, but if the inventor succeeds in rising from the water, he will have performed a feat that has never yet been accomplished with a self-propelled aeroplane.

THE RAVAUD "AEROSCAPHE," SHOWING THE FLOATS UPON WHICH THE AEROPLANE IS MOUNTED.

THE RAVAUD AERO-HYDROPLANE.

ELECTROLYTIC REDUCTION OF INDIGO.

AN attempt to reduce indigo to indigo white by the electrolysis of a solution of sodium carbonate containing finely divided indigo in suspension having proved unsuccessful, the failure was attributed to the possible recombination of the nascent hydrogen atoms into inert molecules, before coming in contact with the particles of indigo. The correctness of this theory was proved by the success of the experiment when a conducting powder, graphite or metal filings, was mixed with the indigo. The caustic soda which is set free by electrolysis aids in effecting the complete solution of the indigo-white. In theory, the process is perfect, but its practical application presents certain difficulties. The mixture of the conducting powder and indigo must not be so intimate or so compact as to prevent its penetration by and suspension in the liquid. The electrodes must be of uniform character and must possess a moderate degree of conductivity, as otherwise the reduction takes place only at the edge of the cathode, and the yield is diminished. It is diminished, also, if the powders are too coarse or insufficiently mixed. About 4½ kilowatt hours are required for the reduction of 1 pound of indigo. On account of the evolution of oxygen at the anode the bath is divided by a partition.

M. Marcel Delage, an engineer of Paris, modifies the incandescent gas mantle so as to adapt it for use in a radiator for heating purposes. Such a mantle differs much from the usual one. To make it, he forms a mantle of asbestos thread on the same mold as the gas mantle, and obtains a tube with open mesh. Such tube is cut in proper lengths and the top is drawn together to form a head. To make it more solid, we dip it in silicate of soda, dry and calcine it on a gas burner. Next, and this is essential, it is dipped in a nitrate of cerium solution and again calcined. Such a mantle can be handled and even thrown on the ground without breaking. Its great heat radiating property is due to the cerium salt. The mantle is suspended above a blue flame in the radiator, using say six in a row in an open-front stove form. It heats up very quickly and when burning we have the best use of the gas heat, as a great part of the heat is radiated horizontally. The radiator also has an agreeable appearance owing to the bright glow.

THE HUMAN EYE.

WHAT MAY BE SEEN AT THE BACK OF IT.

BY F. SAVORGNAN DI BRAZZA.

The eye of all the superior animals, including that of man, is nothing more nor less than a "dark room" of such perfection that the cleverest manufacturer of optical instruments and photographic cameras could not hope to copy it. The globe of the eye consists, as everyone knows, of a kind of sphere, flattened on the upper and under sides and possessing a prominent anterior part, called the cornea. It may be considered as being composed of four special parts. I. A protective part, represented by the anterior part of the cornea and the posterior part of the sclerotic coat. II. One of vision, consisting principally of the retina. III. One of reflection, consisting of a number of transparent membranes, the crystalline lens, aqueous humor and vitreous body. IV. The apparatus of *accommodation*, which permits objects at different distances to be distinguished, and is represented by the ciliary processes and the conjoined crystalline lens. The latter, by means of an appropriate system of muscles, is able to augment or diminish its transverse diameter according to whether the object to be seen is near or far off. No photographic camera possesses such a perfect object-glass as that of the human eye; no camera can be fitted with an apparatus of such instantaneous focus, based on a simple modification of the curvature of its lenses.

The rays of light penetrate the eye and reach the retina by passing through the refracting media, and their quantity is regulated by the iris, which works in the same way as the diaphragm of the photographic camera. The perception of surrounding objects is accomplished at the back of the eye by means of the aforementioned nervous membrane, the retina. At the point where the optic nerve penetrates the eyeball, its numerous fibers spread out like a fan, branching out to infinity and, radiating in all directions, arrange themselves in a uniform manner. At their extremity are found the cells of vision, which, on account of their respective shapes, are called *cones* and *rods*. The function of the two kinds of cells is quite different. The cones are found in the *fovea centralis*, at the point where the perception of objects is accomplished through the concentration of the rays of light. The rods, on the other hand, are found at the edge of the retina, thus forming the circle which surrounds the fovea. On the boundary between the two parts are found cones and rods mixed together. A clever young Italian oculist thinks that the rods are merely young cells which become transformed by degrees into cones, taking the place of any of the latter which die off. Such are the visionary cells properly so called. A clear and explanatory group of rods and cones is shown. They can easily be distinguished one from the other by the latter being pear-shaped. The normal retina is perfectly transparent; when examined, however, in semi-darkness its coloring is reddish purple, owing to the presence of a pigment of that color (rhodopsin). The existence of this reddish purple pigment is of the greatest importance in distinguishing different-colored objects. The granules of the pigment are extremely movable according to the light which strikes them. Dr. Angelucci, while studying in frogs the migration and stratification of the granules in connection with monochromatic rays of light, discovered that from the effects of a single color the granules arrange themselves in direct relation to the rays which strike them, from red to violet, and this is equivalent to saying that at each instant a ray of light produces a corresponding effect and afterward gives the same sensation. This fact has complete analogy with a well-known physical phenomenon which was applied by the French scientist, Lippmann, in the production of his system of colored photography. This system, called "interferential," is one in which the incidental light which forms the image on the sensitized plate is reflected by a mirror in such manner that the two incidental lights and the reflection "interfere" with each other. There are thus formed, as has been pointed out by Dr. Newhaus, stratifications in the sensitized gelatine, according to the different colors which strike it. After death the retina turns to an opaline or slightly gray tint and changes rapidly. The pigment is found specially in the *fovea centralis*, situated in the center of the cells of vision in the posterior pole of the eye. This region is called by oculists the *macula lutea*, or "yellow spot." Above the rods and cones is found a last stratum of substance, the brown pigment of the eye, or *tapetum nigrum*.

THE HUMAN RETINA, SHOWING RODS AND CONES AND ACCUMULATION OF PIGMENT.

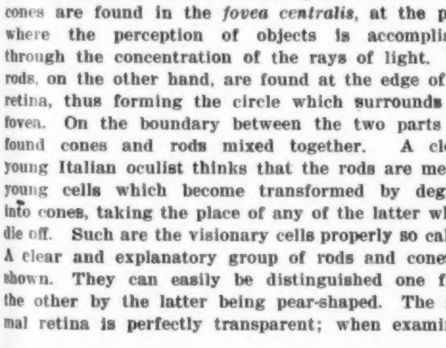
The back of the eye, and especially the retina, by reason of its importance in sight-production, has long been the object of intricate study. Since 1851, when the invention by Helmholtz of the ophthalmoscope gave the first opportunity of genuine scientific research, discoveries have followed fast on one another. Obstacles have certainly been met with in dealing with so delicate and extremely changeable an organ, and one which can with difficulty support a prolonged examination without risk of serious changes, to say nothing of dangerous and painful accidents to the patient. Although the ophthalmoscope permits us to look into the interior of the eye itself, it is possible to obtain only transitory observations by its means. Permanent facts, which are of great importance in the study of every science and in this case of peculiar interest, are unobtainable with the ophthalmoscope. It was, therefore, decided to turn to photography as furnishing the best means we have in our power of obtaining conclusive evidence of the construction of the back of the eye.

Many attempts were made in this direction, and in 1862 a French oculist, Noyes, succeeded in getting photographs of the back of the eye, but these were poor specimens. The results of the studies made by Liebreich, Sinclair, Cohn, and Hope on the human eye and that of the cat, rabbit, etc., only proceeded one step further. It was not till 1887 that an American scientist, Prof. Hove, of Buffalo University, succeeded in obtaining the first real photograph of the back of the eye. This was still a very imperfect picture as to detail, but it was a first step, and with science, as with so many other things, it is always the first step that counts. One of the greatest obstacles encountered in photographing the back of the eye is one which had also been the stumbling block in the case of former attempts. This is the great difficulty of illuminating the back of the eye sufficiently to allow a picture to be taken. The illumination must be sufficient yet not excessive, as in the latter case there is danger of producing modifications in the retina so that a true photograph of the back of a normal eye will not ensue. Prof. Cohn, who has for the last twenty-three years been actively studying the subject, had in 1888 manufactured a special camera fitted with appropriate prisms, but this did not give good results, although not an absolute failure.

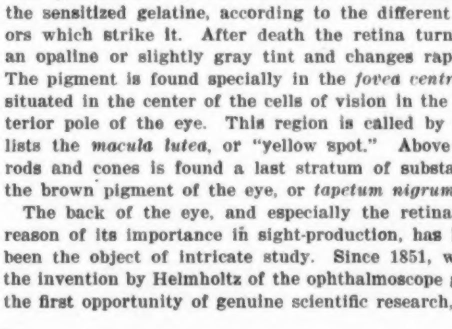
In 1889 Prof. Bagneris, of the University of Nancy, used an equilateral prism for the illumination of the eye; many other attempts were made by different scientists, but it was not until 1891 that a really clear photograph of the retina was obtained and one of scientific interest. This was the work of Prof. Gerloff, and was presented by him, on October 17th of that year, to the Physiological Society of Berlin. This first photograph has now an historical interest, and for this reason it is mentioned. In order to obtain such a photograph the patient was put to a veritable torture, as the following mode of procedure will show:

The eye was, first of all, benumbed with cocaine, then a small basin full of a solution of iodide of sodium was placed in front of the orbit and held in suspension there by means of strips of plaster fixed round the head. The head was then fastened to a support, and the absolute immovability of the patient being secured, he was made to hold a large piece of wax between his teeth. The assistants at this torture of the inquisition naturally tried to find a method which would be less painful and at the same time more certain. Examples of the various attempts at the construction of a suitable apparatus are the one manufactured by the French doctor, Guilloz, in 1893, and that by Thorner in 1896.

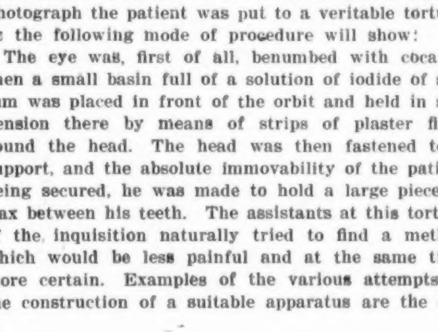
The credit of having discovered a machine which is both practical and simple in construction and working belongs to the Doctors Bonacini and Borghi, of Modena, who, in 1898, presented to the Surgical Society of Modena three splendid photographs, taken with their apparatus, of the back of the eye. The construction is as follows: The source of light has its rays reflected by a mirror; they then pass on to



BACK OF NORMAL EYE.



BACK OF EYE AFFECTED BY CHRONIC ALCOHOLISM.



BACK OF EYE AFFECTED BY TUBERCULOSIS.

THE HUMAN EYE.

* Knowledge and Scientific News.

illuminate the back of the eye through the plano-convex lens. The image given through the convex lens can be seen very clearly by means of the ophthalmic mirror, and can be photographed with an ordinary camera. With the invention of the two doctors of Modena was solved in a simple manner the problem of the illumination of the back of the eye. In the instrument of Bonacini and Borghi the source of light is really composed of two distinct parts, one for inactive light which, as everyone knows, does not injure the eye and by the light of which the eye is focused, while the second part gives a much more vivid light, and is used only at the moment of taking the photograph. This is done by means of an appropriate stop.

A special ophthalmoscope was, in 1902, invented by Prof. Walter Thorner, of Berlin. The instrument was constructed in such a way that the eye could be studied and photographed at the same time. Quite recently Dr. F. Dimmer, of Graz, thanks partly to the large amount of moral and financial support afforded him by the Kaiserl. Akademie der Wissenschaften, of Vienna, has constructed an apparatus which may be said to be perfection, and with it numerous very clear and valuable photographs have been taken, the exposures never lasting longer than the twentieth of a second. The series of Dr. Dimmer's photographs is the only one extant, and is quite unique. Thanks to his courtesy, the writer is able to show some of them here.

The pictures obtained have proved beyond dispute that if the eye is rightly called the mirror of the soul, it may also be called, and with just as much reason, the mirror of the physical state of the body. In the eye, as elsewhere in the body, may be found symptoms of diseases such as consumption and alcoholism, which produce corresponding disturbances of the retina. This fact furnishes to science a new means of diagnosis more certain and rapid than any other. This is of great importance when it is considered that the greater part of the terrible diseases which afflict mankind are easily curable in their initial stage, while they become at a later stage incurable.

In conclusion it may be of interest to describe some curious conditions discovered recently and contemporaneously by several American scientists. It has already been gathered that the rays of light are the cause of the different modifications in the chemical properties of the liquid parts of the eye, in the orientation of the pigment of the retina, etc. Not only is this the fact, but it has also been found that the rays set up in the eye electric currents, which, on account of the part in which they develop, are called *retinal currents*. If the end of a copper wire be placed over the anterior pole of the eye and the other extremity over the posterior pole, just at the middle section of the optic nerve, and if a ray of light is made to fall on the eye, there will run along the wire an electric current from the anterior to the posterior pole. If the ray is very intense the current is strong and prolonged, but the eye does not re-act for some time. If the incidental rays are, on the contrary, weak, then every time a ray enters there is electric variation. The interesting fact is this, that the intensity of these currents produced in succession diminishes in exactly the same way as the change which takes place in muscular fatigue.

The experiments of Prof. Angelo Mosso, made with his ergograph, show that if a muscle is obliged to lift for a long time the same weight, it will tire little by little and at last will cease to work altogether. From the maximum to the minimum strength a curve may be drawn, and this curve is identical with that which shows the electric variations of an eye which is subjected to slight continuous stimulation. For this reason it has been asserted by some that the eye works and exhausts itself after death as it did in life, and, in fact, Woller thinks that all the electrical postmortem phenomena which are found in the muscles and nerves are nothing but the last manifestations of life.

Prof. Bose disputes this theory hotly, saying that vital phenomena are not in question but simple variations in the arrangement of the particles of the body, as is verified by electric phenomena. Bose has come to this conclusion through his own experiments, by which he has demonstrated that all metals when beaten hard respond with an electric current, and that these currents do not develop when the metal is first treated with a narcotic anæsthetic.

SOME COSMICAL ASPECTS OF RADIOACTIVITY.*

THE DISTRIBUTION OF RADIOACTIVE MATTER.

BY E. RUTHERFORD.

MY subject quite naturally divides itself into two parts, one dealing with the properties of the radioactive bodies themselves, and the other with the distribution of radioactive matter throughout the surface of the earth, and throughout the volume of our atmosphere.

It is the latter division of the subject that I wish more particularly to discuss, but before doing so it may be advisable to mention briefly some of the more important properties of the radioactive bodies themselves, so that we may be able to judge of the methods employed to detect and measure the minute quantities of radioactive matter scattered throughout the earth and atmosphere.

I shall not speak here of the early history of radioactivity, which is no doubt well known to most of my audience. As a result of a large amount of detailed investigation, a considerable number of distinct radioactive substances have been isolated. Among the best known of these are uranium, thorium, actinium, radium and polonium, and the numerous substances which arise from their transformation.

Of all the substances separated from uranium or thorium minerals, radium has occupied the most important position. This is partly due to the comparative ease with which it can be chemically isolated and purified, but mainly to its great activity or radiating power, which is about two million times as intense as that of uranium.

The distinguishing feature of radioactive bodies in general, is their power of spontaneously and continuously emitting special types of radiation, of giving heat, and also in some cases of giving out light. These properties in the case of radioactive substances like uranium and thorium, continue, if not indefinitely, at any rate for periods of time measured by millions of years. In the case of radium, the duration of the activity is shorter, but is still measured by thousands of years. This emission of radiations is spontaneous and is completely independent of control, whether by physical or chemical agencies.

I shall take radium as an example of a typical radioelement, but it must be borne in mind that most of the other active substances possess similar radioactive properties. Radium emits three types of rays, called the α, β, and γ rays. The α rays are distinguished by their slight power of penetration of matter. A thin sheet of note paper suffices to cut off the α radiation completely. These rays have been shown to consist of heavy atoms of matter carrying a positive charge of electricity, expelled from the active substances at a speed of about 20,000 miles per second. It seems probable that the α particle consists either of a charged hydrogen or helium atom, and most probably the latter.

The β rays are more penetrating than the α rays and carry a negative charge of electricity and are projected from the active substance at a speed much greater than that of the α particle. Some of the β particles from radium escape with a speed nearly equal to that of light, or 186,000 miles per second. Their apparent mass is only about one-thousandth of that of the α particle, and in fact they are identical with the electrons produced in the cathode ray discharge of a vacuum tube.

The γ rays possess extraordinary penetrating power, passing readily through several inches of iron. It is now fairly certain that the γ rays are ethereal waves similar in character to the well-known Röntgen rays, only of a more penetrating kind.

All of these types of radiation possess in common the properties of acting on a photographic plate and of producing phosphorescence in a certain class of substances, but from the point of view of measurement, their most important property is their power of causing the discharge of electricity from electrified bodies. This property is by far the most delicate test of radioactive matter, and we shall consequently consider it in some detail. If we take an ordinary well-insulated gold-leaf electroscope and charge it so that the gold leaves diverge widely, it is well known that under ordinary conditions with good insulation, the leaves collapse extremely slowly, and over a few minutes' interval the leaves will appear to be almost stationary. Now bring some radioactive matter near the exposed plate of the electroscope. The leaves at once commence to collapse rapidly. This is due to the loss of charge from the electrified system, and takes place with equal rapidity whether the charge is positive or negative. The mechanism by which this discharge is produced has been most carefully studied, and it is known that the effect is due to the property possessed by these radiations of making the volume of the air surrounding the electroscope a partial conductor of electricity. The radiations in passing through a gas produce a number of positively and negatively charged carriers or "ions." These ions move in an electric field. If, for example, the electroscope is charged positively, the negative ions are drawn toward the charged system. The discharging effect is thus due to the drawing in of a great number of negatively charged ions to the positively charged conductor, or *vice versa*. The moment the radioactive substance is removed, the rapid movement of the leaves at once ceases.

This property of the radiations of ionizing the air or other gas is an extraordinarily delicate test of the presence of radioactive matter. I bring up near the electroscope a watch glass on which has been evaporated a solution, containing only one millionth of a gramme of radium bromide. The leaves collapse in a few seconds. If I place the watch glass on the plate attached to the electroscope, a charge given to the electroscope is almost instantly dissipated. The discharging effect in this case is due mostly to the α rays. This can be shown by placing a sheet of ordinary paper, which absorbs the α rays, over the watch glass—the rate of collapse of the leaves becomes now much slower. The residual discharging effect is then due to the β and γ rays from the small quantity of radium.

From the point of view of measurement, a millionth of a gramme of radium produces far too large an effect. In practice it is found that a quantity of radium measured by one thousand millionth (10^{-9}) of a gramme produces an effect of magnitude suitable for accurate measurement. With care, in a suitably designed electroscope, it is possible to measure the presence of one hundredth of this latter amount and in some cases one thousandth. The electroscope is thus capable of detecting by its increased rate of discharge a quantity of radium measuring 10^{-12} of a gramme. As an agent for detecting minutest quantities of radioactive matter, the electroscope is far more sensitive than the spectroscope.

Such measurements do not of themselves throw any light upon the type of radioactive matter which produces the discharge. It would be difficult, for example, to be sure whether the radioactive matter present was radium, actinium or thorium. But there is another property of these substances which allows us to distinguish readily between them. Each of the substances, radium, thorium, and actinium, gives off steadily a radioactive "emanation" or gas which has very intense radioactive properties. If a current of air, for example, is passed over a thorium or actinium compound and then carried into an electroscope, a rapid collapse of the leaves is observed. This is due to the radiation from the emanation, which produces a large number of ions in the air with which it is mixed. In the case of radium, the emanation does not escape from a solid compound, but is readily released by heat or by solution. I have here a solution of radium in a closed bottle. The emanation has collected in the air space above the solution, and on passing a slow stream of air through the solution into the electroscope, some of this emanation is carried with it, and as you see, causes an extremely rapid discharge of the electroscope. If the emanation were left in the electroscope, it would preserve its discharging power for several weeks. The discharging effect would not be constant but would decrease to half value in four days, to one-quarter value in eight days, and so on; and would still be appreciable after a month's interval. In fact, the radium emanation is an unstable substance which breaks up with the emission of α particles. On an average, half of it breaks up in four days. The emanations of thorium and actinium are chemically quite distinct from that of radium and can be at once distinguished from it by the rapid rate at which their activity dies away with time. The emanation of thorium falls to half value in 54 seconds, and that of actinium in 3.9 seconds.

The production of the radioactive emanation by radium offers an extremely simple and reliable method

* Journal of the Royal Astronomical Society of Canada.

of determining not only whether radium is present, but also of measuring accurately the quantity present. Suppose, for example, that we wish to determine the amount of radium present in a given specimen of rock. This is dissolved and placed in an air-tight vessel and left for about one month. During this time the emanation collects in the solution and the air space above it and reaches a steady equilibrium value where the rate of production of new emanation compensates for the disappearance of emanation due to its further transformation. The solution is then boiled, and the air mixed with emanation is passed into a suitable electroscope and the rate of movement of the gold leaves noted.

If the rate of discharge decreases to half its initial value after about four days, it is certain evidence that the radium emanation is present in the electroscope. The amount of radium in the rock is determined by treating in a similar manner a solution containing a *known* quantity of radium and observing the rate of discharge of the electroscope, produced by the emanation from it. By this method, we are not only able to detect the presence of radium in a substance, but also to determine the amount present with considerable accuracy. In this way, a quantity of radium in a solution of only 10^{-11} gramme can be readily measured.

The emanation from radium is an unstable substance and breaks up into another substance which behaves as a solid and has quite distinct radioactive properties. The inside surface of a vessel containing the radium emanation becomes coated with an invisible deposit of radioactive matter. If the emanation is rapidly blown out by a current of air, this "active deposit," as it is called, remains behind. The activity of this deposit is not permanent, but decays rapidly with the time. After several hours, the activity decreases in a geometrical progression, falling to half value in about 28 minutes. For thorium, the active deposit loses half of its activity in 11 hours, for actinium in 34 minutes. The production of this characteristic active deposit from each emanation offers another very useful method of distinguishing whether thorium, radium, or actinium is present.

An interesting property of the active deposit, which we shall see has played a notable part in the analysis of the radioactive state of the atmosphere, is its concentration on a negatively charged conductor in an electric field. The carriers of the active deposit become in some way positively charged and are drawn into the negative electrode and adhere to it.

RADIOACTIVE STATE OF THE ATMOSPHERE.

I have now passed rapidly over some of the more important properties of radioactive bodies, which have proved of great utility in the attack on the question of the distribution of radioactive matter in the earth and atmosphere. The pioneers in this work were Profs. Elster and Geitel, teachers in the Gymnasium of Wolfenbüttel, Germany, and to these investigators we owe a large amount of the information now collected in this important and rapidly growing branch of radioactivity.

Geitel had observed in 1900 that the open air possessed the property of causing a slow discharge of an electroscope, and showed that this effect was due to the production of positive and negative ions in the air. In seeking for a possible cause of this effect, it occurred to Elster and Geitel that it might be due to the presence of some radioactive matter in the atmosphere. They then tried an extremely bold experiment. I have shown you that the emanations from the radioactive bodies produce an active deposit, which can be concentrated on a negatively charged wire. If any radioactive emanation were present in the atmosphere, the active deposit should collect on a negatively charged wire exposed in it. An insulated wire 20 or 30 meters long (Fig. 1) was strung outside a laboratory window and kept charged negatively to a potential of several thousand volts by means of a battery or electrical machine. After several hours, the wire was rapidly removed, coiled round a frame attached to the electroscope, similar to that shown in Fig. 2, and the rate of discharge of the electroscope observed. The gold leaf was found to collapse rapidly, indicating that some radioactive matter was present upon the wire. The magnitude of this effect was independent of the material of the wire and was conclusively shown to be due entirely to the presence of radioactive matter on its surface.

We must now consider how to determine the *kind* of radioactive matter concentrated upon the wire. In the first place, it is improbable that particles of the solid radioactive bodies like radium, uranium or thorium should be present in the atmosphere. But the emanations from radium, thorium and actinium are gaseous, and if the earth contains these substances, we might reasonably expect that some of the emanation released from them might escape into the atmosphere. We have at once a means of definitely settling this question. If the radium emanation alone is present in the atmosphere, the active deposit collected on the wire should decay at the rate characteristic of radium, i. e., after some hours, the activity should decay exponentially, decreasing to half value every 28 minutes. The rate of decay of the active deposit from the air has been shown to be very similar to this, so we conclude that the radium emanation is present in the atmosphere.

The experiment of Elster and Geitel in Germany was repeated by Rutherford and Allan in Montreal and by Prof. McLennan in Toronto, and the results showed that the air of Canada is as radioactive as that of Germany. Falling rain or snow is also radioactive, and its activity decays at the characteristic rate to be expected if the falling rain or snow collects upon it the active deposit of radium distributed throughout the atmosphere.

Preliminary experiments showed that most of the radioactive effect of the atmosphere was due to the presence of the radium emanation. Bumstead, in New Haven, and Blanc, in Italy, have, however, clearly shown that in these localities some thorium emanation is also present. This can be tested in a very simple way. A wire is made active by exposure as negative electrode to the open air for several days. On removal, part of the activity due to the active deposit of radium decays rapidly. After five or six hours, an activity still remains which decays much more slowly, decreasing to half of its value every eleven hours. This is the rate of decay characteristic of the active deposit of thorium and shows that the thorium emanation must also be present in the atmosphere. In some parts of Italy, Blanc has recently shown that fully 70 per cent of the activity on the wire must be ascribed to thorium, but apparently the effect due to radium predominates in most other localities.

We may, consequently, conclude that the atmosphere over the surface of the earth contains everywhere small quantities of the radium and thorium emanation and also the active substances arising from their transformations *in situ* in the atmosphere. The

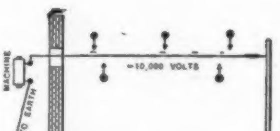


FIG. 1

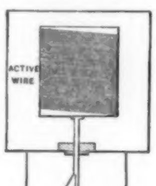


FIG. 2

amount of ionization thus produced is small, but can be accurately measured by apparatus specially designed by Ebert for the purpose. By means of a fan driven by a spring motor, a steady current of air is drawn between two concentric cylinders. The inner insulated cylinder is charged and connected with an electroscope. As the ionized air passes between the cylinders, the ions are removed by the strong electric field between them. The rate of discharge of the electroscope serves as a measure of the number of ions per cubic centimeter of the volume of outside air. In the open air there are usually about 1,500 ions per cubic centimeter of the air; the number is not constant but fluctuates considerably. This number of ions present in the atmosphere is extraordinarily small compared with the number of un-ionized molecules. Each cubic centimeter of air contains about 4×10^{19} molecules, so that on an average only an infinitesimal proportion of the molecules are ionized at one time. While this ionization appears very insignificant, needing a delicate electroscope to detect and measure it, yet it has a very important bearing on the electrical state of the atmosphere.

We must bear in mind that all of us are continuously inhaling the radium and thorium emanations and their products, and ionized air. In addition we are continuously undergoing a type of mild X-ray treatment, for the β and γ rays from the earth and atmosphere continuously pass into and through our bodies. We are, in fact, subjected to a continuous bombardment by the radiations from active matter and are fortunately quite unaware of it. Some have considered that possibly the presence of radioactive matter and ionized air in the atmosphere may play some part in physiological processes, but this is a question quite outside the scope of my address.

An examination of the electrical state of the atmosphere shows that the upper atmosphere is nearly always positively charged, so that the earth must be negatively electrified. There is consequently an electric field normal to the earth which causes a steady movement of the positive ions in the air toward the earth and a corresponding movement of negative ions upward. The latter must tend to dissipate rapidly the positive electricity in the upper atmosphere.

There are many theories as to the origin and maintenance of the positive charge in the upper atmosphere. One very plausible hypothesis supposes that the electrical state of the atmosphere largely results from the radioactive matter distributed throughout it. The appearance of positive electricity in the upper atmosphere is in this view due to the effect of falling rain carrying the negative charge to earth; for it is found that rain is always negatively electrified. The presence of an ionized layer of gas between the upper atmosphere and the earth tends continually to dissipate the positive charge left behind, and this ordinarily prevents the increase of positive electricity to the danger limit, when lightning discharges would pass to the earth. It thus appears probable that the insignificant amount of radioactive matter in the atmosphere plays an important rôle in causing and controlling the electrical state of the atmosphere.

AMOUNT OF RADIUM EMANATION IN THE ATMOSPHERE.

The amount of radium emanation in the air per cubic centimeter of its volume is extremely small, but can be measured by several methods. This problem has been attacked by A. S. Eve of Montreal, who found that a cubic kilometer of the atmosphere contains an amount of emanation equivalent to that liberated from about half a gramme of radium bromide in radioactive equilibrium. Assuming that the amount of emanation in the air over the land surface of the globe is about the same as in the neighborhood of Montreal, and that on an average this distribution is uniform over a height of ten kilometers of the atmosphere, he concluded that the total amount of radium emanation in the atmosphere was equal to that liberated from about 200 tons of radium bromide in equilibrium. It is probable that the amount of radium emanation over the sea is less than that over the land, and is mainly conveyed there by winds from the land, but there is still some uncertainty on that important question.

As I mentioned before, it is extremely improbable that much solid radium in the form of fine particles exists in the air, so that for the supply of emanation to the atmosphere we must look to some external source. We shall now discuss the evidence which leads us to believe that the supply of emanation to the atmosphere is kept up by its steady escape from the surface crust of the earth.

(To be concluded.)

THE WORLD'S WINE PRODUCTION.

THE following on the production of wine in 1908 is from the London Financial Times:

Interesting statistics have been compiled by authorities in France and in this country (England) from which it appears that the world's production of wine in 1908 amounted to 3,866,575,000 gallons, a falling off of 30,889,000 gallons as compared with the previous year. By far and away the most important producer is France, whose output last year amounted to 1,331,995,000 gallons, as compared with the previous year's production of 1,453,546,000 gallons. Italy comes next with 1,064,800,000 gallons, also showing a reduction as compared with the previous year amounting to 121,000,000 gallons. The other big producers, in order of volume of output, are: Spain, 473,000,000 gallons; Algeria, 171,682,000 gallons; Austria 136,400,000 gallons; Hungary, 121,000,000 gallons; Portugal, 85,800,000 gallons; Bulgaria, 63,800,000 gallons; Russia, 61,600,000 gallons; Chile, 52,800,000 gallons; Germany, 50,600,000 gallons; Roumania, 48,400,000 gallons; Turkey and Cyprus, 39,600,000 gallons; Greece, 39,600,000 gallons; United States, 39,600,000 gallons; and the Argentine Republic, 27,500,000 gallons. The outstanding feature of the statistics is the great increase recorded in the production of Spain, amounting to 73,000,000 gallons; of Germany, amounting to 9,000,000 gallons; and of Austria and Hungary, amounting to 59,500,000 gallons and 53,000,000 gallons, respectively.

It is easy to see that if the length of time timbers can be used is doubled, only half as much timber will be required as before, and only one-half as much money will need to be spent in the purchase of timber. Moreover, many woods which were for a long time considered almost worthless can be treated and made to last as long as the scarcer and more expensive kinds. Of the actual saving in dollars and cents through preservative treatment, a fence post may serve as one example. The post is of loblolly pine, and costs, untreated, about 8 cents, or, including the cost of setting, 14 cents. It lasts about two years. Compounding interest at 5 per cent, the annual charge of such a post is 7.53 cents; that is, it costs 7.53 cents a year to keep the post in service. Preservative treatment costing 10 cents will increase its length of life to about eighteen years. In this case the total cost of the post, set, is 24 cents, which, compounded at 5 per cent, gives an annual charge of 2.04 cents. Thus the saving due to treatment is 5.49 cents a year. Assuming that there are 200 posts per mile, there is a saving each year for every mile of fence of a sum equivalent to the interest on $219.60.

SUB-AQUEOUS PHOTOGRAPHY.—III.*

PHOTOGRAPHING AQUATIC ANIMALS IN THEIR NATURAL ENVIRONMENT.

BY JACOB REIGHARD, PROFESSOR OF ZOOLOGY, UNIVERSITY OF MICHIGAN.

Concluded from Supplement No. 1738, page 270.

A NEW SUBAQUATIC APPARATUS.

WHEN a camera for subaquatic use is made after the ordinary type the box must be securely closed before submerging it in order to protect the lens and the plates from the action of the water. While the camera is under water it is not possible to remove the plates or plate holder in order to substitute a ground glass for them. It is therefore impossible to focus, and the camera must be adjusted to the desired focus before immersing it. This was the method adopted by Boutan in his third apparatus. It would be possible to construct a camera that might be focused under water by means of a focusing scale such as is provided in those hand cameras arranged to be focused without the use of a ground glass, the operator estimating the distance of the object and then setting the camera for a corresponding division on the focusing scale. This method is of value for more distant objects and with rather slow lenses of great focal depth. When very rapid lenses are focused on near objects only those objects are in focus that lie nearly in one plane. Thus a very accurate adjustment of the camera is necessary in order to bring any near object into sharp focus, and this is not possible when the distance of the object must be estimated and the focusing accomplished by means of a scale. In subaquatic photography the objects to be photographed are all near and if instantaneous work is to be done the lens must be very rapid. It is therefore important to be able to focus accurately on the ground glass under water, and this might be accomplished by using two identical cameras (twin camera) united so as to form one instrument. One of these contains the plates and has a lens provided with a shutter. The other camera carries the ground glass. The same focusing mechanism operates both cameras, so that when a sharp image is formed on the ground glass of the one an identical image strikes the sensitive plate in the other when the shutter is operated. One of the cameras serves merely as a focusing finder of full size. A camera of this type properly constructed of metal could undoubtedly be used successfully under water, though it has the disadvantage of being unnecessarily cumbersome and expensive.

The Camera.—All of the advantages of the twin camera are to be had by using a reflecting camera, which is at the same time both lighter and less expensive. The principle of the reflecting camera is shown in Fig. 13, which represents diagrammatically such a camera in longitudinal section. The ground glass (*gl*) is placed, not at the back of the camera, as is usual, but in the top. The operator, holding the camera in front of him, looks in the direction indicated by the upper arrow, at the ground glass through the

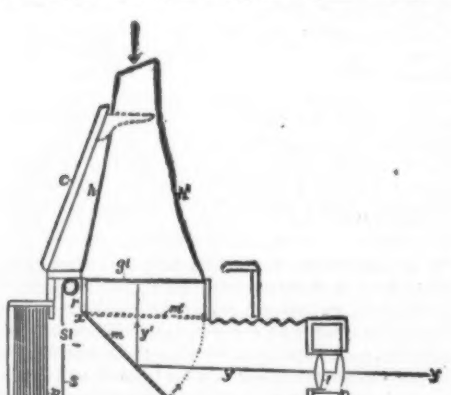


Fig. 13.—A Reflecting Camera Shown in Section, with Magazine Plate Holder Attached.

gl, ground glass; *h h'*, hood; *l*, lens; *m*, mirror in position during focusing; *m'*, mirror, showing position during exposure; *p*, sensitive plate; *r* and *r'*, rollers of focal plane shutter; *s*, the shutter; *sl*, slot in shutter; *x*, hinge on which mirror turns; *y y y'*, ray of light traversing the lens and reflected from the mirror to the ground glass.

hood (*h h'*), which takes the place of a focusing cloth. The interior of the camera contains a mirror (*m*), which extends from beneath the back edge of the ground glass downward and forward at an angle of 45 deg. The mirror is hinged at *x* to the top of the camera. When it is in the position shown at *m* in the figure the space between the back of the mirror and the back of the camera is quite dark. Light entering through the lens is reflected by the mirror and

Fig. 15.—Photograph Showing the Method of Using the Reflecting Camera when Inclosed in the Water-tight Box for Subaquatic Work.

The upper part of the box covering the hood rises above the surface, while the lower part, containing the camera proper, is under water. The operator is looking into the hood through the plate glass in the top of the box. With his right hand he focuses; with his left makes the exposure.

strikes the ground glass, as shown by the line *y y y'*. The image as seen on the ground glass by the operator looking down through the hood is, on account of the action of the mirror, an erect image, not an inverted image such as one sees on the ground glass in the back of an ordinary camera. It is also an image of the full size permitted by the plate and the lens, not a reduced image such as one sees in a finder. The shutter (*s*) is a focal plane shutter situated at the back of the camera just in front of the plate (*p*). Such a shutter is essentially a roller curtain of black cloth with a slot (*sl*) across it at one point. The width of the slot may be regulated. The shutter is wound upon an upper roller (*r*) until the slot is upon the roller. The exposure is made by causing the curtain to unwind from the upper roller (*r*) and wind upon the lower roller (*r'*) so that the slot passes very rapidly across the face of the plate. The length of the exposure depends on the width of the slot and the rate at which it moves. The rate may be varied by changing the tension of the spring which actuates the lower roller. The operator holds the camera in front of him with both hands while he looks down at the ground glass through the opening in the hood. With one hand he focuses. When the object appears in sharp focus and in the desired position on the ground glass, he presses a button with the other hand. This causes the mirror to swing on its hinge to the position shown by the dotted outline *m'* beneath the ground glass. In this position the mirror excludes light which might otherwise enter the camera through the ground glass. At the same time the change in position of the mirror permits the light, which was before reflected to the ground glass, to fall upon the plate. The adjustment is such that an image which is in sharp focus on the ground glass will be in sharp focus on the plate when the mirror changes position. The image does not actually strike the plate so long as the shutter is wound upon either roller. Before the instrument is to be used the shutter is wound on the upper roller. When the mirror in swinging upward reaches the position *m'* the shutter is released from the upper roller and taken up on the lower roller. As the slot passes across the plate from above downward, the image falls through the slot onto the plate in successive strips corresponding to the width of the slot.

The advantages of this form of camera are the following:

1. The operator sees a full-sized, erect image on the ground glass, while at the same time the sensitive plate is in position for exposure.

2. He is able to focus and to regulate the position of the image on the ground glass up to the instant of exposure.

3. Much more rapid exposures may be made with the focal plane shutter than with the ordinary diaphragm shutter. The diaphragm shutter occupies a considerable time in opening and closing, and during the period of operation prevents the light from passing through the full opening of the lens. If the time from the instant a diaphragm shutter begins to open until it is closed again is one one-hundredth of a second, then a considerable part of this time (usually about 40 per cent) is occupied by the opening and closing. The shutter is then wide open and the lens working at its full opening during only a fraction of the one one-hundredth of a second. With the focal plane shutter, on the other hand, if the slot requires a hundredth of a second to pass a given point on the plate, the lens may be wide open during the whole of that time, so that all the light that the lens is capable of passing reaches the plate during the whole of the exposure. For this reason much more rapid exposures may be made with the focal plane shutter than with the diaphragm shutter.

Various forms of reflecting camera are in the market, and it is possible to obtain a magazine plate holder, which carries 12 plates, arranged to be changed without removing the plate holder from the camera or inserting the dark slide. Such a camera, with the magazine holder, is shown diagrammatically in section in Fig. 13. It is surprising that Boutan, when he was seeking some means of focusing his camera under water, did not make use of the idea of the reflecting camera; for by merely inclosing such a camera in a water-tight metal box and arranging it to be operated from outside the box, he would have a portable apparatus capable of being manipulated under water almost as readily as on land. A reflecting camera was

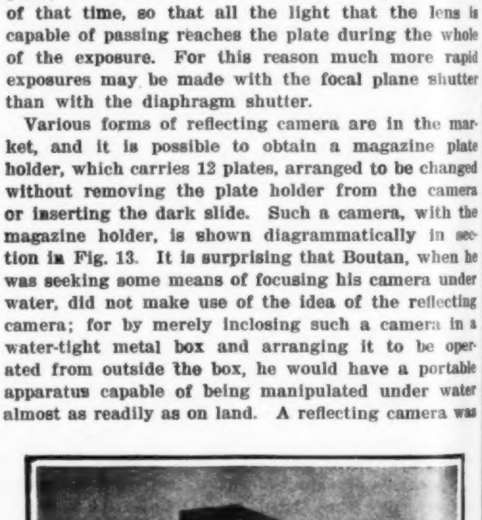


Fig. 14.—Galvanized Iron Box with Plate Glass Front.

Designed by the writer to contain a 5 by 7 reflecting camera when used under water.

manufactured in New York as early as 1886, and was advertised at that time and represented by a Paris agent.

The Water-tight Box.—A 5 by 7 camera of the type just described, with a magazine holder for twelve plates, was used by the writer to obtain submarine photographs at Tortugas, Fla., during the season of 1907. The box (Fig. 14) to contain the camera was made of galvanized iron by a tinsmith. It measures about 17 inches long, 9 inches high, and 10 inches wide. The front is closed by a square of plate glass

* A reprint of a Bulletin published by the Bureau of Fisheries.

cemented with aquarium cement into a groove formed in the metal. At the top is an opening large enough to permit the camera to pass, bottom first, into the box. To the outside of the rim of this opening is soldered half-inch square brass tubing jointed at the

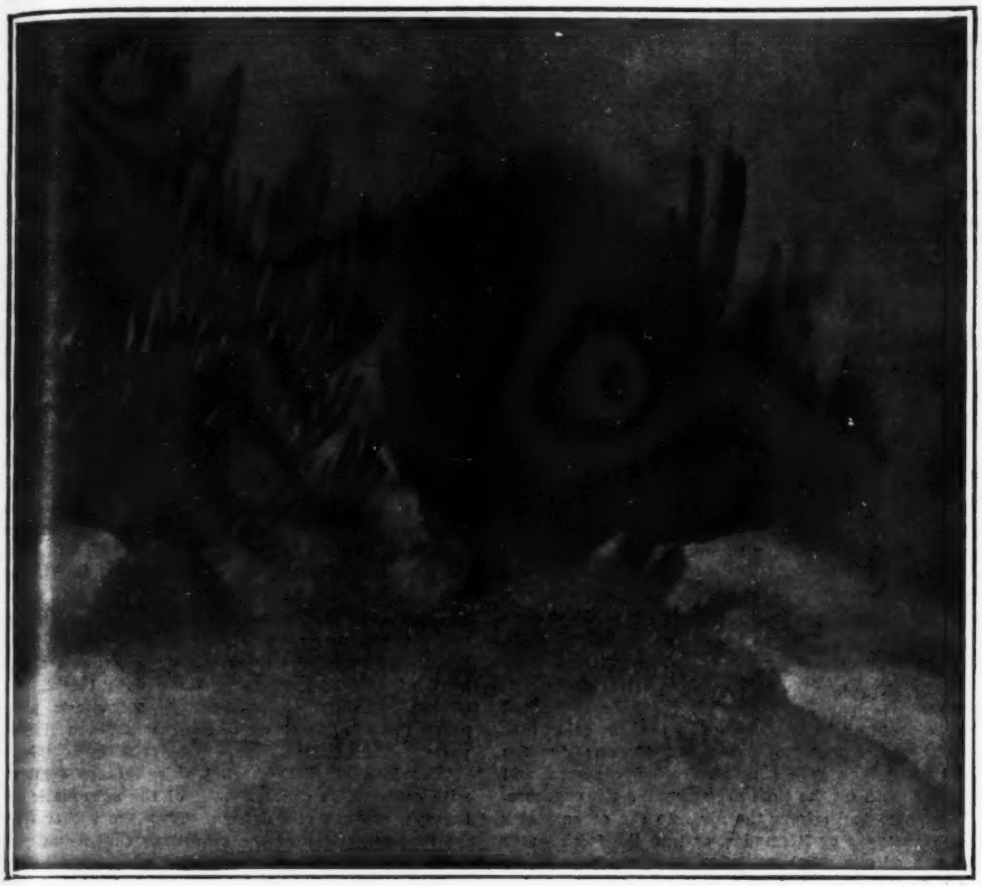


Fig. 16.—Photograph Taken with Camera Submerged.

This photograph is reproduced without retouching from original made on orthochromatic plate with a color screen by the use of a reflecting camera inclosed in the water-tight box described in this paper. The exposure was made in sunlight in about 4 feet of water at 11 A. M. at Tortugas, Fla., and lasted 1/33 second.

corners into a rectangular frame. The upper surface of this frame is made as smooth and as nearly plane as possible. Eight brass screw-bolts are soldered into holes drilled through the frame. They occupy the positions shown in the figure and the threaded end of each projects about three-quarters of an inch above the frame. The cover consists of a flat sheet of metal bordered by a frame of brass identical with that on the box. This frame is perforated by eight openings through which the screw-bolts pass. From the cover there arises an irregular truncated pyramid of galvanized iron, which incloses the hood of the camera. At the top this is closed by a piece of plate glass. By means of wing nuts on the screw-bolts the cover may be tightly clamped to the box, against an intervening gasket of rubber.

On the right-hand side of the box is a large milled head of brass from which a brass stem passes to the interior through a stuffing box, which prevents the entrance of the water along the stem. At its inner end the stem terminates in a two-pronged fork. The stem may be pulled in and out in the stuffing box through a distance of about three-quarters of an inch. When the stem is pushed in, the prongs of the fork engage in two holes drilled in the focusing head of the camera. By turning the milled head on the outside of the box the camera may then be focused. On the opposite side of the box is a second but smaller brass head from which a stem passes through a stuffing box to the interior of the box, and terminates in a flat disk. The disk lies opposite the release pin of the camera by which the mirror and shutter are set in motion. A light spiral spring wound about the stem between the outer head and the stuffing box keeps the stem thrust outward to its full extent. Pressure on the outer head causes the metal disk to strike the release pin so as to make the exposure.

In order to use the box, it is necessary to attach to it a weight heavy enough to submerge all but about the upper 6 inches of the hood. In the experimental apparatus used this weight was made by folding sheet lead to form a flat mass of the dimensions of the bottom of the box. The weight (not shown in the figure) was made slightly wedge shaped lengthwise and was attached to the bottom of the camera by wires passing beneath it and soldered at their ends to the sides of the box. As the camera would, in use, usually be pointed slightly downward, the thicker end of the weight was placed in front, so that the box floated with its front end somewhat lower than its back end.

Using the Apparatus.—The apparatus was used in the following manner: The magazine plate holder containing twelve plates was attached to the camera, the mirror depressed, the shutter set at the desired speed and width of slot, and wound. The dark slide was then drawn from the magazine holder, and the camera, thus made ready for an exposure in air, was placed in the box. Metal cleats soldered to the bottom of the box brought it always to the same position. The head on the right of the box was then pushed in until the fork engaged in the holes in the focusing head of the camera. The top was then put on the box and clamped down by the wing nuts as firmly as possible. The apparatus thus made ready was, when in air, as heavy a load as one man could conveniently carry. It was carried to a boat or, if it was to be operated near shore, to the shore. In working with the help of a boat the operator wades on or near the coral reef with his head and shoulders above the water. The boat, with an attendant on board, is anchored near. The operator, with the help of a water glass, now seeks a favorable place for operations. As he moves about the reef, the fish at first seek shelter in the dark recesses of the coral rock, but if he selects a favorable place and remains quiet they soon reappear. They are at first wary, but soon grow bolder and after half an hour or so pay but little attention to him. There is a great difference in wariness among different species of fish. At first only one or two species appear, demoiselles and slippery-dicks usually, then the number of species gradually increase until the shyest butterfly-fish and parrots come within 6 or 8 feet of the operator. He then has the camera passed to him from the boat. It floats with the upper part of the hood protruding and (Fig. 15) may be easily turned toward any point on the horizon or even tilted so as to be pointed at a considerable angle upward or downward. The operator has now merely to direct the camera at the fish, while he focuses with his right hand. He must often wait some time before the fish come to the point selected or assume the desired attitude. Often they may be enticed by throwing in a bait of crushed sea urchins or pieces of crawfish. They are in constant motion so that he must as constantly focus. He often misses a long-waited opportunity because the fish moves on or takes a wrong attitude before he has had time to focus sharply; but when the favorable time comes he presses the release stem and the exposure is made.

The apparatus must then be lifted into the boat, the cover removed from the box, and the camera taken out in order to reset the shutter and change the plate. It is best that all this be done by the attendant who remains in the boat, as the operator is thus left free to watch the fish, while at the same time the fish are not unduly frightened by the sudden movements that he would make in lifting the camera. With care, however, one person may do all the work necessary. He may anchor the boat near, pull it to him by means of a line, lift in the camera, and make all the necessary adjustments while he himself remains in the water. If the work is done near shore, the camera may be carried to shore after each exposure. In that case an assistant is very desirable, since the return of the operator after each absence disturbs the fish. Moreover, when near shore he is moving over the rock or sand bottom, not over the clean upper surface of the reef, and every considerable movement stirs up the bottom sediment so that some time must pass before the water is again clear enough to permit an exposure to be made. If an assistant is available, he may stand at a considerable distance from the operator, who

Fig. 17.—Photograph Taken with Camera Submerged.

This photograph is reproduced without retouching from original made on orthochromatic plate with a color screen by the use of a reflecting camera inclosed in the water-tight box described in this paper. The exposure was made in sunlight in about 4 feet of water at 11 A. M. at Tortugas, Fla., and lasted 1/33 second.

sends the camera box to him through the water by a quick shove. The assistant, after he has carried it ashore and readjusted it, returns it in the same way.

The opening of the box after each exposure occupies some little time, and during this time favorable opportunities to make exposures are often lost. It would be better if a mechanism were provided by which the plates might be changed without opening the box, which would then remain in the water until twelve exposures had been made. Nevertheless it is possible with the apparatus described to make twelve exposures on coral-reef fish in about two hours including the lifting of the box from the water between exposures and opening it to change plates. Any form of reflecting camera may be used and any form of plate holder. Films may also be used in rolls or packs. In addition to the reflecting camera the operator needs only a metal box of the structure described and of a form suited to his camera. This may be made by any good tinsmith at a cost of a few dollars.

A camera of this type inclosed in a suitable box may be held in the hand while in use, or it may be set upon a tripod of heavy iron, such as is shown in Fig. 8. Such a tripod would best have a top of the form shown in Fig. 2, but made of heavy iron instead of wood. The operator may descend in a diving suit, as Boutan did, and use the camera at the bottom in deep water either while holding it in the hand or while it is supported on a tripod. There should be no difficulty in focusing while looking through the plate-glass window of a diver's casque. For work on the coral reefs of the Tortugas, however, the writer has found that everything may be done from the surface, so that a diver's suit is quite unnecessary. He is told that similar conditions exist at the Bermudas. From his own experience in fresh water he is inclined to believe that probably all the photographic work that it is desirable to do there may be done without the use of a diver's suit. The occasions on which such a suit is really necessary for work in either fresh or salt water are probably extremely rare.

If the objects to be photographed are motionless, or nearly so, time exposures may be made with this apparatus by suitably adjusting the camera before placing it in the box. For this use it is desirable to add to the box a third rod working through a stuffing box and so placed that by means of it the shutter may be released independently of the mirror.

Two photographs made by the method here described are reproduced in Figs. 16 and 17. In Fig. 16 a butterfly-fish (*Chætodon capistratus*) with a stripe through the eye and an eye-like spot on the tail is seen over a flat expanse of coral (*Meandrina*) and at the base of a large, branching gorgonian. The photograph was taken while the fish was in rapid movement. The expanded polyps may be seen on the gorgonian just above the fish and elsewhere. Fig. 17 shows a group of parrot-fishes, of at least three species, and several surgeons against a background of branching gorgonians on a ledge of rock. Near the center is a blue and yellow striped grunt, *Hæmulon flavolineatum*. At the left of this is a blue parrot-fish, *Callyodon cæruleus*. At the right of the grunt is a green parrot-fish, *Callyodon vetula*, about 18 inches long. Beneath the green parrot is a mottled parrot-fish (*Sparisoma?*). Above the green grunt is a second mottled parrot and to the left of this a third. At the extreme left are two surgeons, *Hepatus hepatus*; a third is seen below the green parrot. Above the green parrot, in the background, is a purple sea fan, *Rhipidoglossa*. In most of the fish the details of the markings and the outlines of the scales are clearly seen.

These photographs were taken in water about 4 feet deep with a Goerz II. B lens at a speed of f 5. The exposure was 1/33 second with Seeds P. orthochromatic plate and a No. 3 graphic color screen. The plates were fully timed and were developed rapidly with a strong pyro developer.

The apparatus used by the writer was experimental only and was meant for temporary use. It is easy to suggest improvements, the greatest of which would be a magazine plate holder for at least twelve plates and capable of being operated from outside the box which incloses the camera. There appears to be no such holder on the market. Magazine holders provided with a bag cannot be used even though the leather bag of the plate holder be covered with a rubber bag so attached to the box inclosing the camera that the water cannot enter, for the pressure of the water is such that even when the box is but partly immersed the rubber bag is forced into the box through the opening to which it is attached and the holder cannot then be manipulated. This difficulty would be increased if an attempt were made to use the apparatus at a greater depth. What is needed is a magazine plate holder that presents a rigid exterior everywhere and that may be operated from the outside of the box by means of rods passing to the inside through stuffing boxes.

The box can be improved by reducing to its lowest limit the number of screws used to fasten the cover, for if but one or two screws had to be loosened to open the box much time would be saved in changing plates.

A part of the weight attached to the bottom of the box should be movable, so that it could be fastened either toward the front or toward the back. In this way the box could be made to float with the lens pointed at a considerable angle toward the bottom or toward the surface of the water. The operator would then be spared the very considerable effort necessary to hold the box in position when the lens is directed much above or below the plane in which the box floats.

The purpose of the writer has been to utilize an ordinary reflecting camera for subaquatic work by inclosing it in a suitable water-tight box without in any way lessening its availability for use in air when removed from the box. For use exclusively in water it would be best to design a reflecting camera that could be immersed directly in water without first inclosing it in a box. Such a camera would have to be of metal, water-tight, and would need to have the lens covered by a plate of glass. It would need to have only a small opening at the back on one side for inserting and removing the plates. Such an opening could probably be readily closed by a cover held in place by one or two screws. A camera of this sort, if made rigid enough to withstand the pressure of the water at even moderate depths, would be too heavy for convenient use in air. It would have the advantage of simplicity and increased ease of manipulation.

SOME LIMITATIONS OF SUBAQUATIC PHOTOGRAPHY.

Turbidity of the water sets a limit to subaquatic photography very much as fog or rain or partial darkness restricts photography in air. The water must be clear—that is, apparently free from particles in suspension. If instantaneous work is to be attempted the water must be free from the reddish color that often tinges fresh-water lakes and streams, for the tinge of red or yellow acts as a color screen and greatly lengthens the time necessary for the exposure.

When one looks from the air into the ocean water at the Tortugas or Bermudas, or into the fresh water of some of our northern lakes, it appears to be as clear as the air itself. When the surface is undisturbed, objects on the bottom at depths of 10 to 20 feet appear with as much clearness as though seen through air alone. The impression is created that such water is actually as clear as air, and that the water would offer no more obstruction to the vision of one beneath it than air itself. To test this impression the writer constructed a reflecting water glass somewhat like a reflecting camera without the lens. It was a metal tube 2 feet long, and contained two parallel mirrors, set at an angle of 45 deg. with its long axis, and placed one at each end. By putting one end of this with its mirror beneath the surface and looking into the mirror at the other end, he obtained a view of the subaquatic landscape such as a diver obtains when he looks about him through the glass window in his casque. It is surprising to find how limited is the range of one's vision under these circumstances. Even in the clear sea water about tropical islands objects at a distance of 20 feet begin to appear indistinct, and beyond that distance they fade into a bluish haze which constitutes the background. This haze has not the effect of fog or smoke or twilight. It is as though the near distance were limited on all sides by walls of bluish translucent quartz which merged into the near water. From these walls the fish emerge and grow rapidly more distinct as they approach. Into them they vanish suddenly as they recede.

Subaquatic photographs show the same lack of distance that so impresses the eye. Thus in the photographs Figs. 16 and 17 the distance appears indistinct, partly because the objects are out of focus, but chiefly because they are enveloped in the bluish translucence mentioned above. It is therefore impossible under water to photograph objects at any considerable distance. To the photographer who is unfamiliar with the aspect of the subaquatic landscape this lack of distance in photographs of it seems a defect. But to the artist or naturalist who has seen things as they look to one beneath the water it is really a merit, since it shows these things as they are.

The source of this lack of distance is probably double. It is due in part to the fact that even the clearest water contains very many bodies in suspension, living organisms, and inorganic and organic particles. These, like dust in the atmosphere, interfere with distance vision. It is due also in part to the reflection of the light from the surface of the water. Light which has entered the water from above strikes upon and illuminates various bodies beneath the surface. from these a part of it is reflected to the surface of the water again. If it strikes the surface at an angle of more than 48 deg. 35 min. with the vertical it is totally reflected and passes again into the water. Here it again strikes some submerged body and is again in part reflected to the surface and here again in part re-reflected. Thus shallow water is traversed in every direction by beams of light which intercross at every angle. These illuminate the opaque particles floating in the water and are deflected by reflection. They are also deflected by refraction through the more transparent organisms. In this way probably is produced the background of bluish-white opalescence which characterizes the subaquatic landscape. To one who knows that landscape, the background, hiding many mysteries, adds to it character and beauty. A photograph that failed to show it would be lacking in character. Boutan (1893), who discusses this subject, made use of a blue color screen and believed that he obtained greater distance in his subaquatic pictures by this means. In his more recent work (1900, p. 283) he abandoned the use of the color screen. He obtained clear pictures of near objects by using a shade above the lens, as already described. Boutan appears never to have obtained clear pictures of more distant objects. The writer has made use of an ordinary yellow color screen (graphic No. 3), but is unable to say with certainty that it adds anything to the distance in his pictures. The subject needs further study.

A second characteristic of the subaquatic photographs that strikes the photographer unpleasantly is their flatness. Objects of all sorts appear lacking in thickness or rotundity and do not cast abrupt or heavy shadows. This peculiarity the writer believes to be due to the reflection of light from submerged objects into the water at the water's surface. Light thus reflected on the subaquatic object from the bottom beneath and from the surface above and at all angles takes out of it much of its roundness. It takes out the shadows very much as a photographer in his studio may take them out by a suitable adjustment of reflecting screens. Along with this flatness of the individual objects in the subaquatic photograph there is abundance of contrast between different parts.

This lack of distance and this flatness combined with contrast, so characteristic of the subaquatic photograph, are not real defects. They are rather truthful representations of the conditions that actually obtain. To the photographer accustomed only to photographs made on land they appear to be defects. To one who knows the subaquatic landscape they are, from the artistic standpoint, sources of beauty. From the scientific point of view they undoubtedly place limitations on subaquatic photography.

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Experiments with artificial fertilizers in German vineyards have shown that vines treated exclusively with commercial fertilizers are very much less affected by fungous diseases than vines to which stable manure is applied. There are also other arguments in favor of the exclusive employment of artificial fertilizers.

AERONAUTICS AT GÖTTINGEN UNIVERSITY.*

SOME FIELDS OF RESEARCH WHICH ARE TO BE EXPLORED.

SINCE various errors and misstatements have appeared in the daily press regarding the plans at the University of Göttingen for the scientific study of aeronautics, it is well to give some correct information concerning these and the means at hand for their development.

In the first place, the investigations at Göttingen will consider only the scientific principles of aeronautics. Their practical application must be left to the technical high schools and the various circles of amateurs, particularly the aeronautic clubs.

Not only university funds, i. e., government funds, are available for these investigations, but outside contributions also. In this connection three important bodies must be mentioned in whose formation the lately deceased Ministerial Director Althoff was directly concerned, namely, the International Association of Colleges, the Society for the Study of Motor Airships, and the Göttingen Union of Applied Physics and Mathematics.

In 1893, on the initiative of Althoff and Mommsen, a union was effected of the German universities, by which the universities of Munich, Göttingen, and Vienna, and later those of Leipzig and Berlin, were bound together for the attainment of common aims; and in 1900 this was broadened into a universal association of the colleges of all countries.

The Society for the Study of Motor Airships was inaugurated by His Majesty the Emperor in the autumn of 1905 in Berlin. A capital of one million marks ($250,000) was subscribed in financial circles for the study of the principles of motor airships, and the society was joined by such leading men as Count Zeppelin, Major von Parseval, and Major Gross. The plans of Major von Parseval were acquired, and this gentleman was installed, together with Capt. von Kehler, as business manager. At the instance of Althoff a technical-scientific advisory board was added to the society, and to this belong four citizens of Göttingen, Profs. Klein, Prandtl, Runge, and Wiechert.

The Göttingen Union for the Advancement of Applied Physics and Mathematics was likewise founded at the instance of Althoff in 1898 under the presidency of Privy Councilor Böttinger aus Elberfeld. Its membership includes some notable representatives of industry and of science. Its purpose, as implied in its name, is the support of the efforts of the mathematicians and physicists of Göttingen to extend the technical applications of these two sciences. For effective assistance rendered thanks are due, among others, to the well-conducted Institute of Technical Physics (electrotechnics, mechanics, etc.) of the University of Göttingen.

These three bodies have, with material assistance from the state, greatly influenced and assisted the present movement in Göttingen for the advancement of aeronautics.

At a meeting of the Association of Colleges in 1900, a proposition was made for the international study of atmospheric electricity. Since then the German universities have attacked this subject with the greatest zeal. The Prussian government voted a yearly allowance of 4,400 marks ($1,100) for the study of atmospheric electricity in Göttingen, carried on under the direction of Profs. Riecke and Wiechert. From these studies important results for aeronautics are to be expected, since the electrical condition of the atmosphere is of great significance in meteorological phenomena, such as cloud and storm formations.

The influence of the Society for the Study of Motor Airships has been very important in Göttingen. It is due to the personal relations between Major von Parseval and certain gentlemen of Göttingen, especially Prof. Prandtl, that a model experimental station of the Society for the Study of Motor Airships was built at a cost of about $5,000, and an annual sum of $1,750 was devoted to its maintenance. This experiment station, which lies northwest of the city and is under the direction of Prof. Prandtl, has aims similar to those of the already established model experiment stations for ships. Systematic experiments as to air resistance will be made, such experiments having been hitherto made under incomplete and unsatisfactory conditions, and having yielded, therefore, unsatisfactory results. The programme of the experiments is as follows: Determination of the resistance of balloon models and of various bodies; investigations of the lifting capacity and the resistance of aeroplane surfaces and of complete flying models; investigations of stability; and testing of propellers.

These experiments are made in a long box, 2 x 2 meters (6.56 x 6.56 feet) in cross section, and especial stress is laid on the formation of a perfectly regular and uniform current of air—a condition now almost attained. Before the building of the station, preliminary experiments on a small scale were carried on at the Institute for Applied Mechanics. They resulted in the determination of a more favorable shape for dirigible balloons, which has been used in the latest model of the Parseval airship.

During the past year a special effort has been made in the university to arouse interest in aeronautics among the students by treating hydrodynamic and aerodynamic questions—especially those relating to meteorology—in the mathematical-physical seminar.

Some results of this seminar are given in the article by C. H. Müller on Ship Resistance in the Mathematical Encyclopedia printed as supplement to Article IV, 22, by Kriloff on the Theory of Ships.

Mention should be made of a trip to Paris by Profs. Prandtl, Runge, and Wiechert, for the purpose of studying French attempts at flight. Another interesting event was the opportunity offered about this time to the Göttingen students of a personal meeting with the celebrated English aerodynamic expert Lanchester, whose valuable book on aerodynamics will soon appear in German.

At the annual meeting, in October, 1908, the Göttingen Union took up the subject of the problem of flight. To the interest roused by this discussion is due the decision of the Prussian government to confer on Prof. Prandtl a formal commission for the teaching of aeronautics, together with an allowance of $1,000 annually for instruction and experiment.

During the coming summer there will be given, besides a two-hour lecture course by Prof. Prandtl on the Scientific Principles of Aeronautics, a course on balloon operation by Dr. Bestelmayer.

It was also due to the influence of the Göttingen Union that the new proprietor of the Krupp Works, Herr Krupp von Bohlen-Halbach, put at the disposal of Prof. Wiechert a sum of $2,500 annually for three years for the furtherance of experiments whose ultimate aim is the improvement of methods of observation of electrical and meteorological conditions at great heights. In these experiments use is made of registering instruments, which have been hitherto sent up by manned or unmanned free or captive balloons, or by kites. These methods offer the alternative difficulties of great expense in the case of manned balloons and risk of loss in the others. In the case of captive balloons or kites, on the other hand, the cord seriously interferes with the electric field of the atmosphere, thus uncontrollably affecting the observations. Prof. Wiechert proposes to obviate all these difficulties by sending up the instruments on small motor-propelled flying machines without operators.

Since these flying machines will not be attached by a cord, they must meet two conditions: They must possess sufficient stability to automatically maintain their direction of flight without being affected by chance gusts of wind, and they must be capable of being steered from the ground, perhaps by Hertzian waves. To attain these conditions offers an extremely difficult problem—one, however, which has been already solved in another domain, for torpedoes can be made to hold their path uninfluenced by currents of water, and some very successful results have been obtained at experiments in steering them by means of Hertzian waves. In America a dirigible balloon has been successfully controlled and steered in this way. Hence, it is hoped that a happy solution may be obtained in the case of unmanned flying apparatus; and if so, this will prove of the greatest importance in aeronautics, since maintenance of stability is one of the greatest desiderata for flying machines.

All in all, some $7,350 is at hand at Göttingen for the next year in the domain of aeronautics and meteorology. This sum, however, can be applied only for pure science. Thus, no part of it would be available for the building of man-carrying motor-driven aeroplanes.

This worthy object, as also that of putting to practical use the theoretic discoveries at Göttingen, must be left to amateurs and aeronautic clubs. It is to be hoped that wealthy patrons will be found in Germany, as in France, to donate funds for such a noble sport.

* Extract from a paper read by Prof. F. Klein before the Aeronautical Union of Lower Saxony.

Everybody has heard of the Southern Cross, which is perhaps the most famous of all the constellations. Nobody ever visits the Southern Hemisphere without looking for it, and recording his impressions of it. It has done more to implant in the popular mind an idea of the poetry of the heavens than all the other constellations put together. Yet it is going to destruction. Its four principal stars are all moving in different directions. The star at the top of the cross is moving south, that at the bottom east, that at the left-hand end of the crossbeam north, and that at the right hand west. The ultimate effect will be that no form resembling a cross will be left, its place being taken by a curious right-angled figure.

THE EFFECT OF ILLUMINATING GAS ON LEATHER.

IN connection with a series of experiments on the influence of sulphur in illuminating gas, Mr. Arthur D. Little had occasion to report upon its effect on leather. He states that there has been considerable agitation in England on account of the deterioration of leather book bindings in many of the libraries. A special committee was appointed from the Society for the Encouragement of Arts, Manufacture, and Commerce to inquire into the reasons for the deterioration of leather books. A sub-committee reported that as a result of the experiments which had been undertaken, they were of the opinion that of the deleterious influences to which books are subjected, the fumes of burned gas are the most fatal, owing no doubt to the sulphuric and sulphurous acids which they contain.

Prof. J. Gordon Parker, a well-known English leather chemist, testified before the Board of Trade Committee in 1904 that he had carried out numerous experiments exposing leather to the fumes of burning gas, and found that these fumes rotted the leather so that in time it was absolutely destroyed and crumbled to a powder. He found, moreover, that the leather under these conditions contained sulphuric acid. It developed on questioning Dr. Parker that sulphuric acid is used in the bleaching and dyeing of leather, and that if once used it cannot be successfully washed out. On that account much of the modern leather in books will go to pieces anyway. The leather which Prof. Parker used for his experiments, however, was especially prepared by himself, and was free from any mineral acids. He was very emphatically of the opinion that the amount of sulphur in gas was of great importance in respect to the durability of leather. It was pointed out at the time, however, that in special libraries where considerable quantities of leather-bound books were kept, arrangements might easily be made to light with electricity or oil. It also developed in the inquiry that Prof. Parker's experiments on leather-bound books were carried out in a very small, air-tight room, where a large amount of gas was burned under conditions which caused a precipitation of moisture on the sides of the room and on the leather, and that this moisture would of course contain sulphuric acid. The conditions of his experiments were very far from those of an ordinary library, and it is questionable if, under modern methods of lighting, where very much smaller quantities of gas are used in incandescent mantels, and in rooms where there is any kind of ventilation whatever, the action of the products of combustion of illuminating gas on books is, to say the least, not proven.

Mr. Little points out as demonstrating the relative insignificance of the question of sulphur in gas as a possible factor in the deterioration of leather, that practically all light-weight leathers now go through the process of "chrome tanning." He refers particularly to the Schulz process, in which the skins coming from the beam house are first soaked in a solution of bichromate of potash, and after this has thoroughly penetrated the tissue, the skin is removed to a bath of hyposulphite of soda, to which later a mineral acid, usually muriatic acid, is added to decompose the hyposulphite, with evolution of sulphurous-acid gas and precipitation of sulphur in the minutely-divided form in the bath and throughout the skin, the object of the reaction being the reduction of the chromic acid of the bichromate to chromic oxide, which renders the gelatin of the skin insoluble, and thereby converts it into leather. A considerable proportion of the sulphur precipitated during the reaction is necessarily left within the substance of the skin in a form of extremely minute subdivisions, in which form, of course, the surface presented to oxidation is relatively very great, so that under appropriate conditions, especially as to moisture, a slow oxidation of the sulphur to sulphuric acid is to be expected. That these leathers in fact so seldom deteriorate in use, is due merely to the general absence of conditions favorable for this oxidation. It can, however, be confidently asserted that the danger from deterioration through oxidation of the sulphur already within the leather is so incomparably greater than that likely to result from any sulphur compounds derived from gas burned in the vicinity of the leather, as to render this last-named cause a practically negligible one.

ENGINEERING NOTES.

According to our contemporary, the Engineer, of London, lime cartridges are being used instead of powder or dynamite in mining coal in some parts of Europe. The cartridges contain calcium oxide ground to powder, a ½-inch perforated tube being placed in a groove at one side of the cartridge. After the cartridge has been inserted and tamped, an amount of water approximately equal to the quantity of lime is forced through the tube into the body of the cartridge. The steam thus generated, coupled with the expansion of the lime itself, serves to break down the coal.

The American Shipbuilding Company has closed contracts for three lake freight boats to be built for Eastern interests, whose names for the present are withheld. The boats will be of the 9,000-ton class, 624 feet long, 54 feet beam, and 30 feet deep. They will be built at the Lorain yard. Work will be started on them at once and they will be ready for delivery in the latter part of the summer. This contract makes orders for thirteen boats booked by the company for 1909 delivery. Of these, ten are bulk freighters, one is a package freighter, one a small passenger steamer, and one an oil barge.

The Interborough Rapid Transit Company recently filed plans with the Public Service Commission for the lengthening of the express stations of the Subway to accommodate ten-car trains, and the extension of the local platforms to admit of six-car local trains. The present capacity is respectively eight cars and five cars. It is probable that the Commission will recommend the lengthening of the local platforms to accommodate seven- or eight- instead of six-car trains. If the Interborough proposals are carried through, the capacity of the Subway will be increased about twenty-five per cent, or from 150,000 to 200,000 passengers per day.

A ship brake, which is intended to bring a ship to a stop within the least possible time, is to be fitted experimentally on the old battleship "Indiana." The device consists of a pair of plane vertical surfaces, one on each side of the ship below the waterline. These wings or blades, each of which will be 6 feet wide by 13 feet high, will be attached to the vessel's sides by hinges. Normally they will be in closed position, folded against the sides of the vessel, and they will be held in the closed position by locking bars. When it is desired to stop the vessel suddenly, as in the event of pending collision, the locking bars, which are controlled from the bridge, will be released. They will give an initial opening movement to the brakes, which are then forced open to a position normal to the sides of the vessel, by the inertia of the water.

G. L. Wilson, engineer of maintenance of way of the Twin City Rapid Transit Company, of Minneapolis, believes in the efficiency of cast-welded rail joints, which are being used with success by that company. He states that, to insure good results in cast welding, all the details of the process must be carefully watched. The molds, caps, and screws must be in good order and carefully adjusted. To avoid dampness and the generation of steam when the molten iron is poured into them, the molds should be coated with kerosene or black oil and heated in an oven before they are adjusted to the rails. The cupola charge is made up of half machine scrap and half good quality pig iron. The weight of the joint on the 7-inch 90-pound rail is 160 pounds. Although, during the last six years, this company has welded 13,611 joints on 7-inch and 8-inch rails, there have not been more than a dozen broken joints.

SCIENCE NOTES.

Commendatore Boni, the famous archæologist, has proposed to the Italian Minister of Education that the vacant nunnery on the Palatine, near the Villa Mills, shall be converted into a museum for housing casts of the principal busts scattered about Italy, and thus form a supplement to the Forum Museum and Library now being established in the former convent of S. Francesca Romana.

The first Latin-American Scientific Congress, which was convened in Buenos Aires in 1898, was projected by the Scientific Society of that city, and successfully carried out. It was attended by representatives of twelve Latin-American republics, and yielded results of such importance that a second congress was convened at Montevideo in 1901; and this was followed by a third at Rio Janeiro in 1905. Arrangements were made for a fourth meeting at Santiago, Chile, in 1908, and the Chilean organization committee, feeling that the activities of the congress, which had been limited to the discussion of Latin-American problems and interests chiefly, should be extended to a fully Pan-American scope, decided that the Santiago meeting should be known as "The First Pan-American Scientific Congress."

The large diurnal variation of temperature in India renders impossible the determination of the vertical temperature gradient from kite ascents extending over, say, four or five hours. To get over this difficulty the meteorograph is attached, not to the kite, but to a special carrier which slides along the kite wire. A sail attached to the carrier supplies the power for raising the latter along the wire. On coming in contact with the kite the sail is automatically liberated, and the carrier slips back along the wire and returns to the operator. The whole apparatus weighs about 0.7 kilogramme, of which 120 grammes fall to the portion of the meteorograph. The meteorograph is a development of the Dines kite meteorograph. The chief improvement consists in tracing the records of temperature, pressure, and humidity on a silvered glass disk with "pens" consisting of points of hardened steel. The traces thus obtained are about 0.05 millimeter in thickness, and can be read easily under a microscope. Successful use has been made of the apparatus in the Arabian Sea, where soundings of the atmosphere up to heights of about 1.2 kilometer were obtained in about 15 minutes.

Recent discoveries at Sparta have considerably increased our knowledge of Greek history and life. From a number of inscriptions of the second century —to be precise, dating between A. D. 170 and 190—it seems clear that at this period of the Roman domination, with its tendency to luxury and enervation, there was a recrudescence of the old Spartan spirit, an effort to revive the simplicity and austerity of which Lycurgus was the traditional founder. It appears that during this time "the divine Lucurgus" was at least eleven times elected Patronomos of Sparta—an office corresponding to that of Archon at Athens. Nor was this office a mere sinecure, for the deified Lycurgus being unable to take an active part in the government of the city, a deputy was appointed to maintain the observance of the old-time customs and traditions of the Lycurgean era, including the peculiar ritual associated with the cult of Artemis Orthia. This is the only instance at present known of a deified legendary hero with an acting deputy occupying the position of magistrate on the mainland of Greece, although it was not at all an uncommon arrangement in Asia Minor.—Architect and Contract Reporter.

TRADE NOTES AND FORMULÆ.

Oleat Maury.—A preparation for greasing wool, according to a French patent, is made by the saponification of mixtures of mineral oils and vegetable oils by alkaline carbonates.

Tile-Stove Cement.—A mixture of washed chalk and beaten white of egg is found to be excellent. Joints retain an attractive white color, and in spite of severe heating, remain closed, even immediately adjacent to the fireplace, where it is quite thick and exposed to great heat. At first, the cement, owing to the egg white it contains, will give off an unpleasant, cheesy odor, but this will disappear after a few weeks.

Mouse Poison.—According to Schlesinger, Siegburg, oat malt is made from ordinary oats by kilning, diastasing, and crushing the grains in a roller mill, adding aniline yellow, saccharine, and salicylic acid, moistening with extract of sea leek (squills) and then drying. Mouse porridge is a granulated mixture of 5 parts of carbonate of barium, 1 part sugar and 5 parts of wheat flour, colored gray by charcoal powder.

Stove Polish for Iron Stoves.—To polish heating stoves, the polish employed must be finely comminuted and mixed with silicate of potash and liquid water glass. To heighten the color, take a coffee-spoonful of bronze powder to a half of a pint of water glass, thinned with distilled water. The mixture must be well stirred and applied to the stove, light a fire in it to accelerate drying, and after each drying repeat the coating as many times as desired. We can use with it zinc-white, ultramarine, English red, orange, dark chrome-yellow, red lead, lamp black, or green ultramarine. All the colors must be mixed with warm rain water and diluted 33 per cent water glass, free from sulphur (1 part water glass and 2 parts rain water).

Varnish for Beach Shoes.—Yellow: 150 parts water, 5 parts crystallized borax, 2.5 parts technical glycerine, 0.25 part technical spirits of sal ammoniac, 25 parts white shellac, 0.80 part water-soluble yellow (No. 690), 0.125 part formaline. Orange: 150 parts water, 5 parts crystallized borax, 2.5 parts technical glycerine, 0.25 part technical spirits of sal ammoniac, 22.5 parts ruby shellac, 0.8 part water-soluble orange (R), 0.3 part brown (No. 2923), 0.125 part formaline. Light Brown: 150 parts water, 5 parts crystallized borax, 2 parts technical glycerine, 0.25 part technical spirits of sal ammoniac, 25 parts white shellac, 8 parts water-soluble yellow (No. 690), 0.30 part orange (R), 0.125 part formaline. The glycerine and spirits of sal ammoniac should be mixed in a separate vessel before being turned into the kettle. It is also advisable, before the water begins to boil, to take some of the almost boiling water in a clean vessel and to dissolve the color in it, stirring thoroughly, adding this solution to the contents of the kettle, after the shellac is dissolved.

Luminous Mass.—20 parts of caustic potash, such as may be obtained by heating to redness a dense limestone, for instance, by calcination of the very dense shell of the *Hypopus vulgaris*, is thoroughly mixed with 6 parts of powdered stick sulphur and 2 parts of starch. This mixture is then moistened by the addition, by drops, of 8 parts of a solution of 0.5 part of subnitrate of bismuth and 100 parts of alcohol, adding meanwhile a little hydrochloric acid, so that an intimate distribution of the bismuth is effected. After the alcohol has evaporated into the air, heat the mixture in a covered crucible for about 20 minutes, to a bright red heat, either in a wood charcoal fire or in a gas furnace. After complete cooling, remove the thin skin of gypsum that covers the surface, powder the molten mass and heat again for a quarter of an hour at the same temperature. If the operation has been very carefully conducted, the powder will bake together but slightly at the second heating, so that a moderate pressure will suffice for its fine reduction. A second pulverization, inasmuch as it would affect the luminous property, is to be avoided.

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